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August 1982

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STE/ICE DESIGN GUIDE
FOR
VEHICLE DIAGNOSTIC CONNECTOR ASSEMBLIES

AD-A181 563

Contract DAAK 30-78-C-0105
Work Directive RGD-3/10

Prepared for: Department of the Army
U.S. Army Tank-Automotive Command
Warren, Michigan 48090

Prepared by: RCA Corporation
Government Systems Division
Automated Systems
Burlington, Massachusetts 01803

Approved for public release;
Distribution Unlimited

ERRATA SHEET TO STE/ICE DESIGN GUIDE FOR VEHICLE DIAGNOSTIC CONNECTOR ASSEMBLIES (CR-82-588-003; AUGUST 1982)

Changes required:

Page 16 - Make the following pin letter corrections in Table 2:

Function	Pins
Code Resistor	h,j
DCA Indicator.	D,f,g
Engine Speed	
DCAs 1-9,13	c,d (Shield e)
DCAs 10-12	H,J (Shield K)

Page 28 - Change Figure 9c divider resistor from 0.37K to 1.37K.

Page 44/45 - Note: The Table No. refered to on Table A1 are located in the STE/ICE Military Specification MIL-T-62314(AT), Appendix B.

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FOREWORD

This STE/ICE Design Guide for Vehicle Diagnostic Connector Assembly (DCA) has been prepared in compliance with Work Directive RGD-3/10 of Contract DAAK 30-78-C-0105. Personnel in TACOM Component and Material Function (DRSTA-GBM) and Diagnostic and Electrical Weapon Systems Manager's Office (DRSTA-RGD) have given guidance and valuable suggestions throughout the preparation of this document.

The primary purpose of this Design Guide is to aid manufacturers of Army vehicles in developing Diagnostic Connector Assemblies that will utilize the full capabilities of the STE/ICE. The content of this guide has evolved from on-vehicle experience and extensive consultation with vehicle manufacturers during both the vehicle DCA design phase and the STE/ICE Vehicle integration phase. Review and study of this document will provide direction for most of the questions and problems that first time designers commonly experience.

For additional information and assistance to resolve questions not addressed in this guide and the referenced documents, contact the TACOM Diagnostic and Electrical Weapon Systems Manager's Office (DRSTA-RGD).

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INTRODUCTION

The purpose of the Design Guide is to acquaint vehicle manufacturers with the STE/ICE system and explain how to implement the Diagnostic Connector Assembly (DCA) into their vehicles. The DCA provides the simplest mode of operation for STE/ICE (Simplified Test Equipment for Internal Combustion Engines). The diagnostic connector, generally located in the driver's compartment, terminates a permanently installed vehicle wiring harness which connects to the vehicle's diagnostic test points and transducers.

Chapter 1 describes STE/ICE background, test capabilities, modes of operation, and sources of user instruction and documentation.

Chapter 2 presents "Systems" considerations in developing test requirements, selection of DCA class, and allocation of tests to the DCA or TK mode. DCA Class selection is further aided by information in Appendix A. Guidelines for addition of a second DCA or omission of certain DCA functions are discussed. In addition to installation of a diagnostic harness STE/ICE application requires generation of vehicle test limits, engine constants, technical manuals, and other documentation. The tabulations in Appendix B contain test descriptions that should be reviewed to gain the understanding of STE/ICE capabilities necessary to effectively perform the system application addressed in this Chapter.

The DCA standard components are discussed in Chapter 3. Use of the standard components is strongly recommended to obtain the benefits of evaluations and experience sponsored by TACOM to date.

Chapter 4 presents installation design details. It addresses many questions and problems posed by vehicle manufacturers and provides general guidelines for DCA implementation. A table summary of the VTM input characteristics provides additional information on the measurement channels and is particularly useful if vehicle powered instrumentation or non-DCA standard components are to be interfaced to the VTM. Appendix C supplements this information with specific details and illustrations for making vehicle connections. Chapter 4 plus Appendix C are the primary guides for the detail design of the DCA.

Finally, suggestions for testing and verifying the DCA harness prior to connecting a VTM are given in Chapter 5.

This Design Guide supplements the Generic DCA Interface defined in Appendix B of STE/ICE Specification MIL-T-62314. Additional information on the STE/ICE set and its use can be found in the STE/ICE Operator's Organizational Maintenance Manual TM-9-4910-571-12&P. If questions still persist, further information can be obtained from the TACOM Diagnostic and Electrical Weapon Systems Manager's Office (DRSTA-RGD).

CHAPTER 1

THE STE/ICE SYSTEM

1.1 Background

The modern U.S. military services are faced with a vehicle fleet maintenance problem of growing proportions. The increasing complexity of military vehicles, restricted accessibility of components and limited availability of skilled mechanics have compounded the problem of malfunction diagnosis. The seriousness of the problem is magnified by the fact that maintenance concepts must better support and be compatible with land combat operations. Vehicle readiness on the battlefield is a prime objective. Vehicles must be serviced rapidly especially at the edge of battle. Assessment of vehicle condtions and maintenance is critical to sustain combat operations.

The goal of high levels of vehicle readiness at economical costs was impossible to achieve with former method of malfunction diagnosis. Incorrect diagnosis of vehicle faults often resulted in replacement, evacuation, or "repair" or serviceable parts. The mechanics's need for help in diagnosing vehicle component problems has been thoroughly documented by the Army. A study[1] found that thirty to sixty-five percent of engine/engine accessory components replaced were, in fact, serviceable. Twenty-one percent of the replaced engines were found to be fully operational.

The major causes of incorrect engine and vehicle diagnosis are:

- Obsolete test equipment.
- Mechanic training limitations.
- Technical Manuals are difficult to use.
- Maintainability/Testability not emphasized in vehicle developments.

The fact that faulty malfunction diagnosis continued to be a major problem in vehicle maintenance is illustrated by an Army survey that found thirty percent of a sample group of one hundred eighteen track vehicle mechanics incorrectly diagnosed mechanical malfunctions. In a test conducted at Fort Carson, thirty-five percent of the generators, regulators, alternators, distributors and starters returned as unusable were actually serviceable.

Similar evaluations were recorded during visits to other armor units in CONUS and in USAREUR. This situation reflects unsuitable test equipment, inadequate technical documentation, and shortcomings in training.

Recognition of the many vehicle maintenance problems and the limitations of all test equipment led the Army to issue a System Development Requirement (SDR) in 1971 for test equipment to assist the organizational level mechanic in fault detection on internal combustion engine powered materiel. The SDR directed that the test equipment must be:

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(1) "Faulty Diagnosis of Repairable Components", a report to the board inquiry on the Army Logistics Systems, Lieutenant General Frederick J. Brown, Chairman, 1966.

- Simple to use and understand (self-teaching).
- Easily connected to vehicle.
- Capable of testing gasoline and diesel vehicles.
- Operable in Army tactical/automotive environment.
- Low cost for deployment at Organizational Level (motor pool).
- Adaptable to expanded test requirements.
- Accompanied by simplified troubleshooting instructions.

The test equipment had to permit the mechanic to detect the troubles in engines including engine electrical and fuel systems in as little as twenty minutes. The goals of this development were to increase vehicle readiness, reduce maintenance labor costs, and eliminate the needless replacement of components.

1.2 STE/ICE - General Information

Simplified Test Equipment for Internal Combustion Engines (STE/ICE) is the result of new developments in vehicle test technology. The test capability is based on vehicle failure histories, cost analysis, and extensive consultation with personnel at all levels of maintenance. STE/ICE satisfies the vehicle fleet support requirement for power plants and related accessories of tactical and combat vehicles at the Organizational Maintenance level and can support many requirements at the Direct Support level.

STE/ICE is microprocessor-based and field-portable. It provides significantly increased capability over former Army test and diagnostic equipment. It was designed for ease of use, low cost, and high reliability. It is militarized for operation in maintenance shops and in the field. In addition to measurements such as speed, pressure, vacuum, temperature, voltage, current, resistance, starter peak current, dwell, and timing, the system electronically determines compression unbalance in engine cylinders and performs power tests on gasoline and diesel engines without external dynamometers. STE/ICE was type classified "standard" by the U.S. Army on September 27, 1978, after completion of Design Tests and Operational Tests.

The STE/ICE system includes three major items of equipment:

- Vehicle Test Meter (VTM).
- Transducer Kit (TK).
- Generic Diagnostic Connector Assembly (DCA).

The VTM and TK comprise the STE/ICE Set which is carried to the vehicle in a transit case (see Figure 1). The DCA is built into vehicles to be tested. It includes transducers, electrical connections and a vehicle harness which brings all test points to a conveniently-mounted diagnostic connector (Figure 2).

The VTM interfaces to the vehicle through the DCA or with the Transducer Kit (TK). Although the DCA is the mechanic's optimized mode of operation, practical limitations preclude wiring of all possible measurements. The vehicle manufacturer should be aware that the Transducer Kit can supplement DCA measurements. It also provides test capability for other vehicle systems and vehicles not equipped with DCAs.

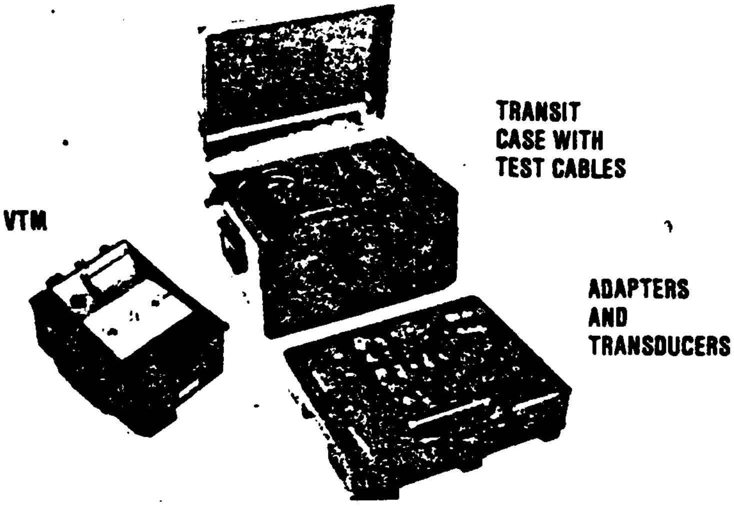


Figure 1. STE/ICE Set

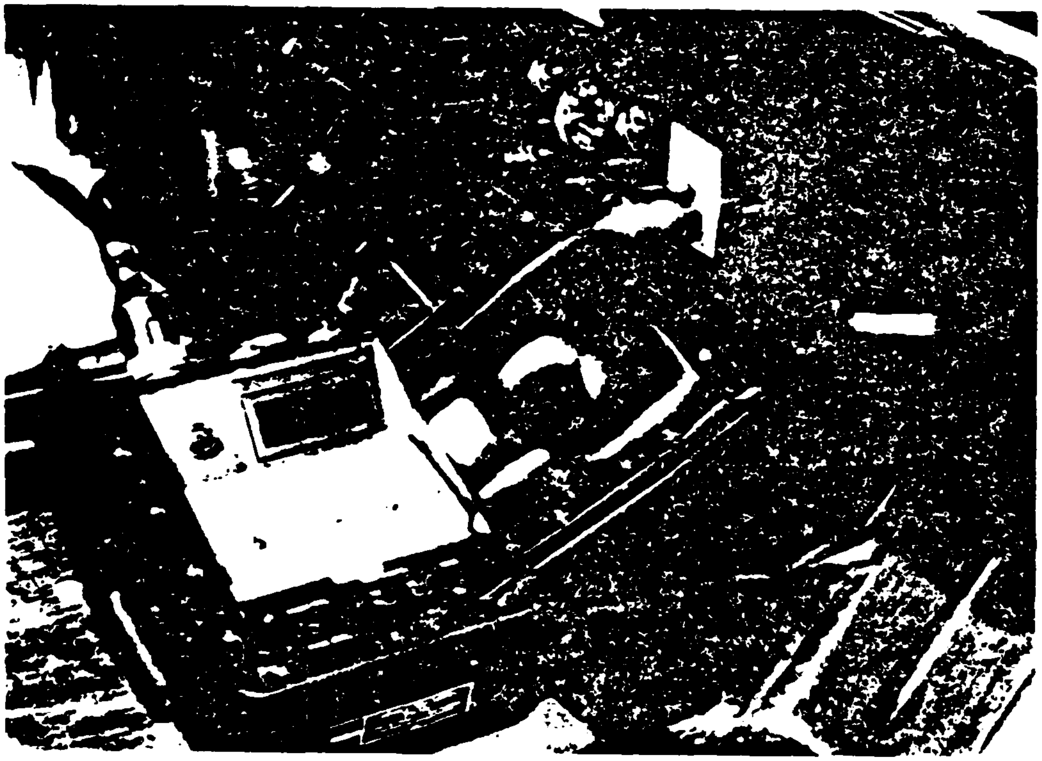


Figure 2. Diagnostic Connector Assembly Application

The Transducer Kit contains two pressure transducers (vacuum to 25 psi, and 25 to 1,000 psi), a clamp-on current probe (0 - 1500 amps), a tachometer for diesel engine speed measurement, and electrical test probes. Various cables, adapters, and fittings are also included to allow the test system to connect to the vehicle under test and to assure that the system is adaptable to the military fleet of vehicles.

The design of the STE/ICE VTM was influenced by two philosophies. The first was to minimize complexity at the operator interface and the second was to make maximum use of a microprocessor to decrease the need for special purpose hardware. The microprocessor and fourteen thousand words of read-only-memory (ROM) accomplish the many VTM tasks by manipulating the associated input, processing and display hardware. Figure 3 shows the STE/ICE general purpose hardware architecture.

The VTM (Figure 4) measures vehicle parameters and displays the results as either Pass/Fail or a digital value in units familiar to the mechanic (psi, RPM, Volts, etc.). Readings are properly scaled, the mechanic does not decide where the decimal point belongs or what range of measurement is read. For convenience, many of the tests and limit values are listed on flip cards mounted on the VTM and on Vehicle Test Cards.

Simplicity of operation is illustrated by standard tests where the mechanic simply inputs a test number and the measurement result appears on the digital display. For each test of this type, the microprocessor executes the following tasks:

- Reads TEST SELECT switches.
- Validates test selection and operation conditions. Displays error message if required.
- Selects test multiplexer channel.
- Controls channel characteristics, offsets, gain, bandwidth, etc.
- Controls special purpose signal processing circuitry.
- Reads analog to digital converter.
- Scales and outputs results to display.

Furthermore, the microprocessor makes possible the system's special tests for:

- Cylinder Compression Unbalance.
- Engine Power.
- Battery Resistance and Starter Current Peak.
- Spark Ignition Timing.
- Confidence and Self-Tests.

STE/ICE has self-teaching features and built-in reference aids which make it easy to use. Prompting messages remind the mechanic to "crank the engine", or perform other test actions. Error Messages alert the operator to improper test numbers, operation mode, or incorrect vehicle operation. Confidence (self-test) messages indicate VTM performance and are also used at the DS level as an aid in repairing a faulty VTM. There are seven status messages, eight prompting messages, seventeen operator error messages and forty-four Confidence error codes.

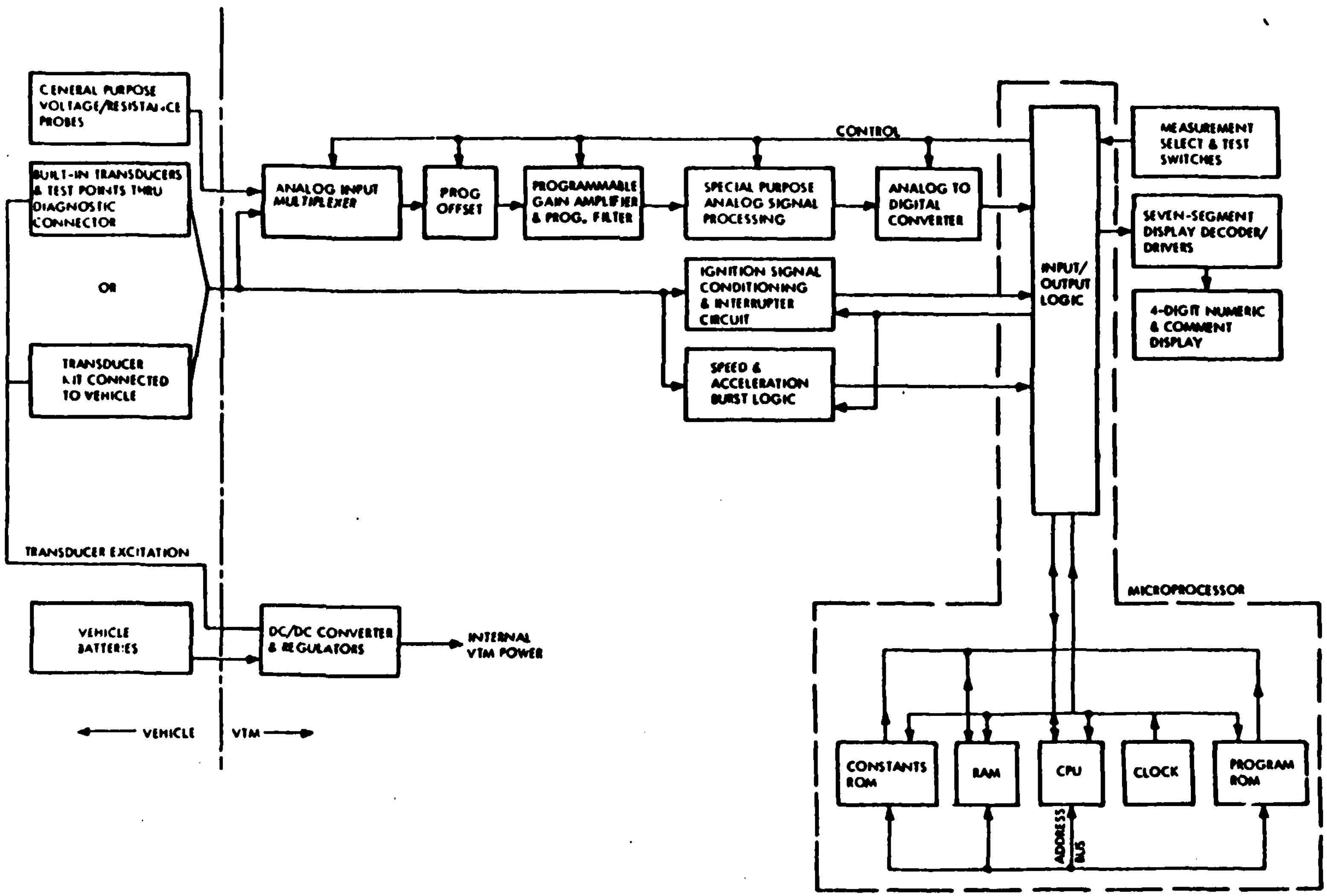


Figure 3. STE/ICE System Architecture

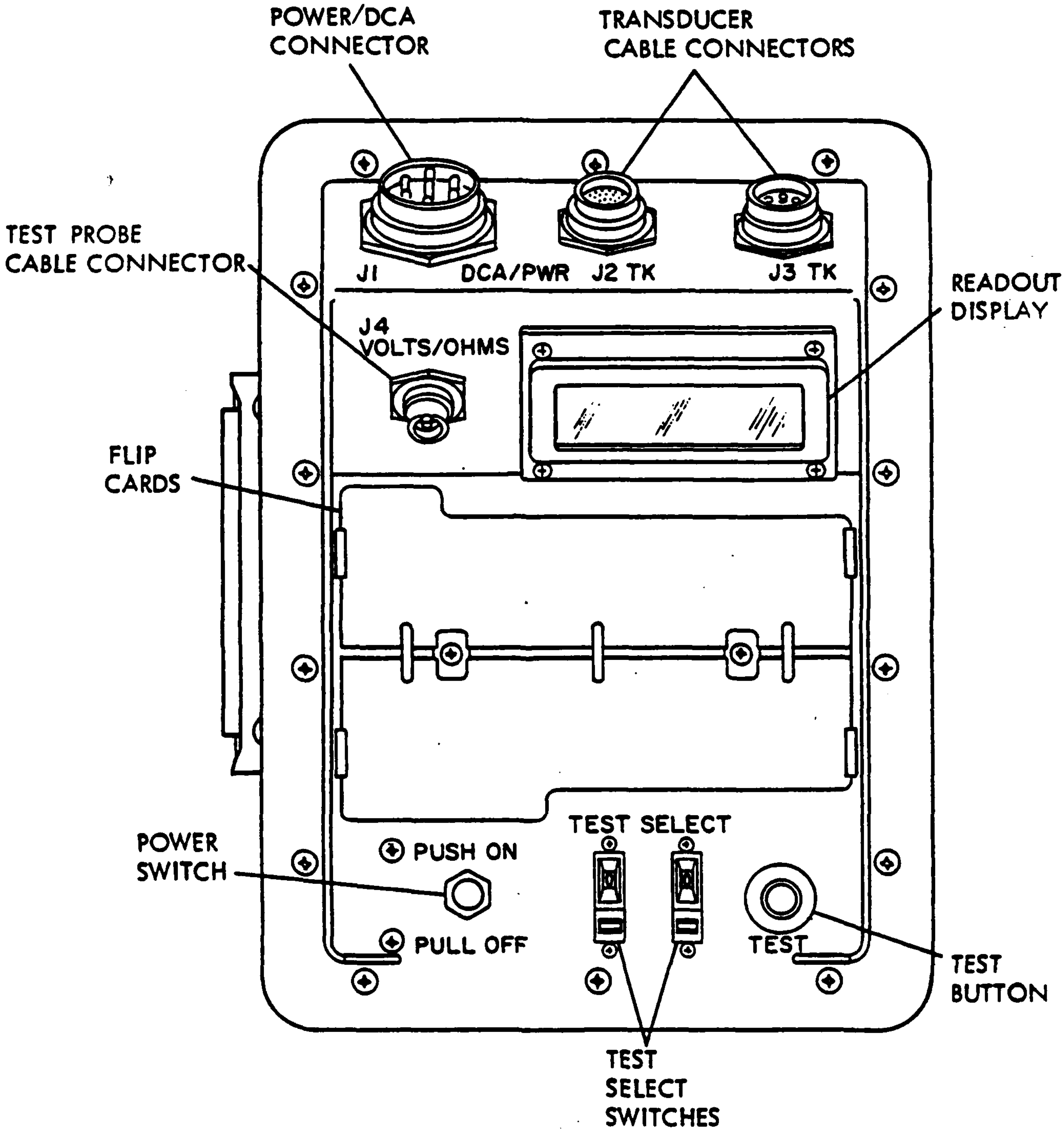


Figure 4. Vehicle Test Meter

1.3 Generic DCA Concept

Vehicles are categorized into fourteen generic classes based on engine, fuel system, and the similarity of sensor complement. Each generic DCA is identified with a code resistor in the vehicle harness. The VTM reads the code resistor and provides the proper processing and conversion constants to the vehicle sensed signals. Further test control is provided by the DCA Indicator, also wired into the harness, and the Vehicle Identification Code (VID). The DCA Indicator identifies the transducer excitation source and speed sensor information. The VID is dialed into the VTM switches (2 digits) to identify stored vehicle dependent test constants which vary within a DCA class for Power Test, Compression Unbalance, and Starter Current First Peak Test. To permit STE/ICE application to an ever expanding number of vehicle types, modifications to the VTM are in the design stage to allow field insertion of the test constants. The modifications will not affect compatibility of the DCAs with either the presently fielded or future modified VTMs. Application of the DCA classes is listed below. A more detailed description is found in Appendix A.

Generic DCA Type numbers	Vehicle Class
1 - 4	Medium-sized diesel engines
5 - 9	Large diesel engines
10 - 12	Spark ignition engines
13	Optional second DCA connector
14	Reserved

1.4 User Instructions and Documentation

Direction and guidance for the use of STE/ICE are provided by the STE/ICE Operator's Manual, Vehicle Test Cards, and VTM flip cards (operating instructions on the VTM).

The primary guide for set orientation and operation is the STE/ICE Operator's Organizational Maintenance Manual. The manual provides step by step serviceability tests and troubleshooting procedures applicable to eighteen combat and tactical vehicles. The procedures are incorporated as symptom oriented flow charts with logical deductions made after each test.

The Operator's Manual is supplemented by a Vehicle Test Card for each vehicle. Each card includes a summary of tests, limits, vehicle specific information, entry codes, VTM operator and error messages, TK hook-up instruction, and test sequence required to evaluate vehicle serviceability. Figure 5 shows a Test Card structured for DCA testing of the M2/M3 Fighting Vehicle System.

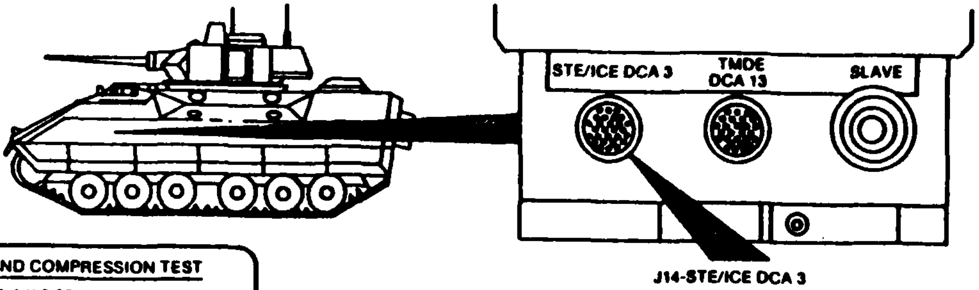
Also, operating instructions, tests, VTM messages and test limits for specific vehicles are given on the VTM flip cards.

Once the mechanic becomes familiar with STE/ICE and the diagnostic logic process, he will be able to troubleshoot by using the flip cards on the VTM and the Vehicle Test Card for that vehicle.

For new vehicles to be fielded with DCAs, tests and troubleshooting procedures using STE/ICE are to be incorporated into the vehicle manuals. The vehicle test

card heretofore issued as a separate document will be included in the troubleshooting portion of the vehicle technical manual. Remember that the DCA tests can be supplemented with additional TK tests and procedures. The STE/ICE Operator's Manual and Vehicle Test Cards can serve as guides for the content and format of information to be presented in the Vehicle Technical Manual.

M2-M3 - VEHICLE TEST CARD - VID 16



PRE-TEST INSPECTION

1 FAN BELTS
2 OIL LEVEL
3 COOLANT LEVEL
4 FUEL LEVEL
5 BATTERIES

INITIAL ENTRY

TEST 66 CONFIDENCE TEST (SECOND ENTRY - 99)
TEST 80 VID ENTRY - 16
TEST 81 VID DISPLAY
TEST 82 DCA ID

CONTROL OF NEXT TEST

01 INTERLEAVE WITH SPEED
02 DISPLAY MIN VALUE
03 DISPLAY MAX VALUE
04 DISPLAY PEAK-TO-PEAK VALUE

POWER AND COMPRESSION TEST

POWER TEST 13 AND COMPRESSION UNBALANCE TEST 14 AND 15 CANNOT BE RUN ON THIS VEHICLE AT THIS TIME (MAR 82). THE VTM WILL DISPLAY E004 EVEN THOUGH A VALID VID HAS BEEN ENTERED INTO THE VTM. NO LIMITS ON POWER TEST 12 CAN BE SET WITH THIS ENGINE. A RECORD ON EACH VEHICLE MAY BE KEPT USING POWER TEST 12. A CHANGE FROM THE NORMAL VALUE FOR THE VEHICLE INDICATES FAILURE OF THE POWER TEST.

ERROR MESSAGES

E000 INFORMATION NOT AVAILABLE
E001 TEST NON-EXISTENT
E002 TRANSDUCER NOT CONNECTED
E003 TEST NOT VALID IN THIS DCA
E004 VID OR NUMBER OF CYL NOT ENTERED
E005 CAL NOT PERFORMED
E007 NUMBER OF CYL CONFLICTS WITH VID
E008 TEST PROBE NOT CONNECTED
E009 ENGINE NOT RUNNING
E010 BAD VID
E011 ACCEL/DECEL TIME TOO LARGE
E012 TACH PICKUP MISSING
E013 BAD DATA
E014 BAD NUMBER OF CYLINDERS
E016 TEST DISCONTINUED EXCESSIVE TIME
9999 OVERLOAD OR NUMBER EXCEEDS DISPLAY CAPABILITY

OPERATOR MESSAGES

PASS TEST SUCCESSFULLY COMPLETED
CAL OFFSET TEST IN PROGRESS RELEASE TEST BUTTON
CIP INITIATE CI POWER SIMULATION
CYL ENTER NUMBER OF CYLINDERS OR CYLINDER PAIRS
FAIL TEST FAILED
GO CRANK ENGINE
OFF IF CRANKING, STOP; IF CI POWER, DECELERATE
UEN ENTER VEHICLE IDENTIFICATION NUMBER
.... VTM ACCEPTING DATA OR INITIAL TURN-ON
0086 DIAL 99 PUSH TEST BUTTON
8888 CHECK DISPLAY

VEHICLE READINESS TESTS

TEST NAME	TEST NO	OFFSET LIMITS	OPERATING CONDITION	LIMITS MIN	LIMITS NORMAL	LIMITS MAX	UNITS
BATTERY VOLTAGE	67	—	ENGINE OFF	[illegible]	—	—	VOLTS
	01 67	—	LIGHTS ON 1000-1200 RPM	24	27.5-28.5	28.5	VOLTS
BATTERY ELECTROLYTE LEVEL	61	-	PAIR 61	—	PASS	—	PASS/FAIL
ENGINE RPM	10	-	IDLE NO LOAD	775	-	[illegible]	RPM
	10		GOVERNOR SPEED NO LOAD	[illegible]	—	[illegible]	RPM
ENGINE OIL PRESSURE	35	±10	WARM ENGINE IDLE	5	—	35	PSI
AIR CLEANER FILTER ΔP	01 20	±.5	NO LOAD [illegible] RPM	—	—	4.0	IN H_2O
FUEL RAIL PRESSURE	01 24	±45	ROAD TEST [illegible] RPM	[illegible]	—	[illegible]	PSI
FUEL FILTER RESTRICTION	28	—	GOVERNOR SPEED NO LOAD	—	PASS	—	PASS/FAIL
FUEL PUMP VOLTAGE	27	—	IDLE	[illegible]	[illegible]	[illegible]	VOLTS
ALTERNATOR VOLTAGE	01 62	—	LIGHTS ON, 1000-1200 RPM				
			CHECK ALTERNATOR ADJUSTING PLUG POSITION: TROPIC	[illegible]	27	[illegible]	VOLTS
			NORMAL	[illegible]	[illegible]	[illegible]	VOLTS
			ARCTIC	[illegible]	[illegible]	[illegible]	VOLTS
TURBO OUTLET PRESSURE	01 20	±7.5	ROAD TEST @ [illegible] RPM	27	—	[illegible]	IN HG
POWER	12	—	—	—	—	—	RPM/SEC
COMPRESSION UNBALANCE	14	—	WARM ENGINE	—	—	11	%
STARTER CURRENT †	72	±100	CRANK ON GO	1400	—	1700	AMPS

OPTIONAL VEHICLE TESTS

TEST NAME	TEST NO	OFFSET LIMITS	OPERATING CONDITION	LIMITS MIN	LIMITS NORMAL	LIMITS MAX	UNITS
ENGINE COOLANT TEMP	[illegible]	*	PROPER ENGINE WARMUP	170	-	[illegible]	F
ENGINE OIL TEMPERATURE	37	*	PROPER ENGINE WARMUP	[illegible]	—	[illegible]	F
ALTERNATOR NEGATIVE CABLE DROP	01 [illegible]	—	1000-1200 RPM	—	—	0.5	VOLTS
STARTING MOTOR CURRENT AVERAGE †	[illegible]	±100	CRANKING	-	[illegible]	—	AMPS
BATTERY RESISTANCE †	73	±130	CRANK ON GO	—	—	13	MILLIOHMS
STARTER CIRCUIT RESISTANCE †	74	±150	CRANK ON GO	—	[illegible]	[illegible]	MILLIOHMS
BATTERY RESISTANCE CHANGE †	75	±100	CRANK ON GO	—	—	[illegible]	MILLIOHMS SEC
STARTER SOLENOID VOLTAGE	70	—	CRANKING	16	—	—	VOLTS
STARTER NEGATIVE CABLE DROP	[illegible]	—	CRANKING	-	—	1.2	VOLTS
STARTER POSITIVE TERMINAL VOLTAGE	[illegible]	-	CRANKING	17	—	—	VOLTS

* TEMPERATURE IS READ DIRECTLY AFTER PERFORMING OFFSET TEST

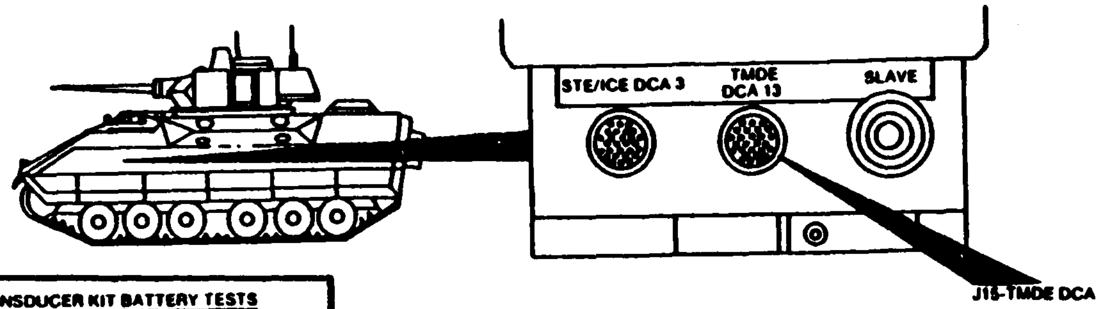
† IF OFFSET IS PERFORMED FOR ANY ONE TESTS 72 73 74 75 OR 80 OFFSET NEED NOT BE REPEATED WHEN DOING THE OTHER TESTS

NOTE: TEST LIMITS GIVEN ARE ADVISORY ONLY AND ARE NOT NECESSARILY THE SAME AS MANUFACTURER'S SPECIFICATIONS

SAMPLE

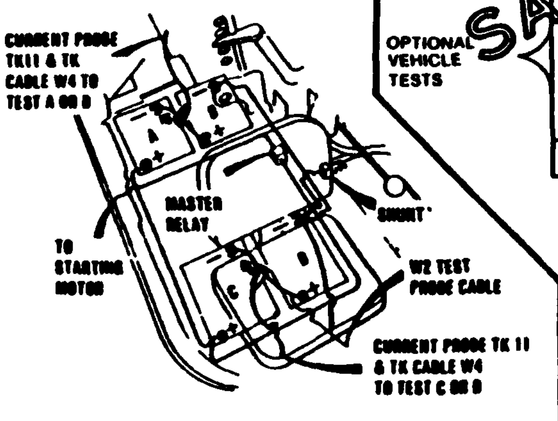
Figure 5. Sample Vehicle Test Card (Front) Page 1 of 2

M2-M3 VEHICLE TEST CARD - VID 16



TRANSDUCER KIT BATTERY TESTS

IN THE DCA MODE, BATTERY TESTS ARE PERFORMED ON THE 4 BATTERIES AS A GROUP. IT MAY SOMETIMES BE NECESSARY TO ISOLATE TO A SINGLE BAD BATTERY. TO DO THIS THE TEST LEADS AND THE CURRENT PROBE ARE USED. THE TEST LEADS ARE CONNECTED TO THE BATTERY UNDER TEST. THE CURRENT PROBE IS PLACED ON THE JUMPER BETWEEN THE PAIR OF BATTERIES THAT INCLUDES THE BATTERY UNDER TEST. THE DIAGRAM BELOW SHOWS THE CURRENT PROBE POSITIONS. THE TEST LEADS ARE SHOWN IN POSITION TO TEST BATTERY D



TESTING INDIVIDUAL BATTERIES WITH TEST PROBE CABLE AND CURRENT PROBE

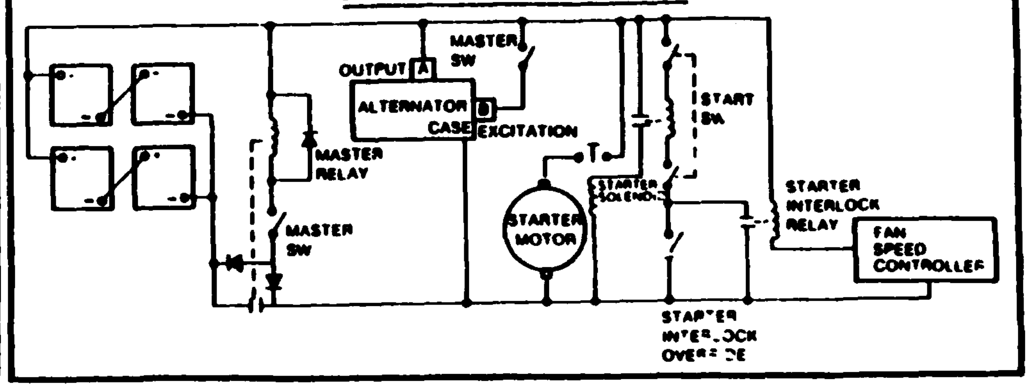
TEST 70 STARTER CIRCUIT RESISTANCE 20 MILLIOHMS, MAX
TEST 80 AVERAGE CRANKING CURRENT 250-400 AMPS
TEST 77 INTERNAL BATTERY RESISTANCE 13 MILLIOHMS, MAX SINGLE BATTERY
TEST 79 BATTERY RESISTANCE CHANGE 25 MILLIOHMS/SEC MAX SINGLE BATTERY

	TEST NAME	TEST NO	OFFSET LIMITS	OPERATING CONDITION	LIMITS MIN	LIMITS NORM	LIMITS MAX	UNITS
VEHICLE READINESS TESTS	TRANSMISSION OIL PRESSURE	01 30	±40	1800 RPM	103	-	180	PSI
	ALTERNATOR EXCITATION VOLTAGE	01 27	-	LIGHTS ON 1000-1200 RPM	26 7	27	27 6	VOLTS
	BATTERY ELECTROLYTE LEVEL	61	-	PAIR #2	-	PASS	-	PASS/FAIL
OPTIONAL VEHICLE TESTS	TRANSMISSION OIL TEMPERATURE	37	*	PROPER ENGINE WARM-UP	180	-	280	F
	ENGINE RPM	10	-	IDLE, NO LOAD	775	-	825	RPM
		10	-	GOVERNOR SPEED, NO LOAD	2000	-	2080	RPM
	STARTER SWITCH RETURN VOLTAGE	16	-	CRANKING	3 3	-	-	VOLTS
	RAMP HYDRAULIC MOTOR	67	-	RAMP SWITCH ON	18	-	-	VOLTS
	RAMP LOWERING SOLENOID	70	-	RAMP SWITCH OFF	-	0 0	-	VOLTS

* TEMPERATURE IS READ DIRECTLY AFTER PERFORMING OFFSET TEST

SAMPLE

STARTING/CHARGING CIRCUIT DIAGRAM



NOTE: TEST LIMITS GIVEN ARE ADVISORY ONLY AND ARE NOT NECESSARILY THE SAME AS MANUFACTURER'S SPECIFICATIONS

Figure 5. Sample Vehicle Test Card (Back) Page 2 of 2

CHAPTER 2

VEHICLE TEST CONSIDERATIONS

The main goal of STE/ICE is to rapidly assess vehicle operational readiness and, if a problem exists, to quickly fault isolate to a replaceable item. Implementing a generic DCA on your vehicle will provide the parameters to satisfy most of the test requirements for the power plant and related accessories. If additional parameters or other vehicle system tests are necessary, they may be implemented with an optional second DCA and/or with the Transducer Kit mode of tests. A study of the STE/ICE tests and Generic DCA parameter listings are useful in verifying that the proper DCA selection has been made and in effectively assigning tests to the diagnostic connector assembly or to the transducer kit mode of tests.

2.1 Selection of DCA Class

DCA class selection for your vehicle is based on engine type, fuel system, sensor assignment, and VTM processing and scaling. Refer to the column labeled Engine Types in Appendix Table A-1 to find the DCA class that best describes your engine. Next refer to Table A-2 to determine similarity to the vehicles serviced by STE/ICE. Detailed on this table are the vehicles and engines assigned to the classes. These two tables should enable you to determine the primary DCA class for your vehicle type. Next, review the detailed Individual DCA Description for the selected class in STE/ICE Specification MIL-T-62314(AT), Appendix B. The DCA description defines the basic test function, vehicle connection and required signal to be accessed by the diagnostic connector.

2.2 Vehicle Test Needs

A good starting point for allocation of STE/ICE tests to the Diagnostic Connector Assembly or to the TK mode of operation is Appendix B of this document which provides summary information on all tests useful in applying STE/ICE to your vehicle.

Table B-1 describes VTM Control, Confidence and Entry tests used in all modes of operation.

Table B-2 describes tests generally available to DCAs 1 through 12 and identifies the diagnostic connector pins used for each test. The pin information is particularly useful in identifying which tests can be performed through the vehicle connections of your DCA. Note that tests in Table B-2 are not available to all DCAs and that pin allocations may vary by DCA. DCA applicability is shown in the right column. Note also that DCAs 10, 11, and 12 are for spark ignition engines.

In most cases the tests available for each DCA class are adequate to meet the vehicle's organizational maintenance requirements. However, should you decide that the available tests do not adequately maintain and diagnose your vehicle, you can implement a second DCA connector - DCA class number 13. Table B-3 lists the additional voltage, temperature, and pressure tests available on DCA 13. Examples of tests that could be implemented are transmission oil pressure or temperature, hydraulic system pressure, or electrical test points. Be aware that some measurements are essential as vehicle/engine design parameters, but are not required for serviceability or diagnostic evaluation.

Specific information and examples of vehicle test points and connections are given in Appendix C. Together Appendices B and C provide a guide on where to make the vehicle connections. The tests in the Transducer Kit mode of operation are summarized in Table B-4. Extensive test capability paralleling the DCA mode is available with test probes and transducers that are temporarily connected to the vehicle. These tests can supplement the tests available at the DCA connector(s), particularly if the test points are readily accessible or if deeper diagnosis is required. Make note of which TK tests will be used on your vehicle and insure that the vehicle test point is readily accessible and compatible with STE/ICE.

2.3. Test Allocation Matrix

To organize and allocate tests to the primary DCA or optional second DCA, the structuring of a Test Matrix as illustrated in Table 1 is recommended. In the first column, list the tests that are necessary for maintaining and diagnosing your vehicle. Then for each test, determine if the primary DCA (the vehicle's own DCA class) accesses the parameter to perform this test. If this test is available, place a YES in the column; if it is not available, place a NO in the column and proceed to check if this test can be performed using the secondary DCA connector (DCA 13). Place a YES or NO in this column depending on the results of your investigation. A column for TK tests may be added if desired.

As a general test philosophy, DCA tests should diagnose and isolate faults to a depth that results in maintenance actions or replacement of a component allowed at the Organizational level of maintenance.

Table 1. Sample Test Allocation Matrix

VEHICLE PARAMETER	PRIMARY DCA DCA 3	SECONDARY DCA DCA 13
Alternator Output Voltage	Yes	
Alternator Field Voltage	Yes	
Air Cleaner Filter ΔP	Yes	
Battery Voltage	Yes	
Battery Resistance	Yes	
Battery Resistance Change	Yes	
Compression Unbalance	Yes	
Engine Oil Pressure	Yes	
Engine Oil Temperature	Yes	
Engine Oil Filter ΔP	Yes	
Engine Coolant Temperature	Yes	
Engine RPM	Yes	
Fuel Supply Pressure	Yes	
Fuel Filter ΔP	Yes	
Hydraulic System Pressure	No	Yes

Table 1. Sample Test Allocation Matrix (Continued)

VEHICLE PARAMETER	PRIMARY DCA DCA 3	SECONDARY DCA DCA 13
Hydraulic Steering Filter ΔP	No	Yes
Power Test	Yes	
Starter Current First Peak	Yes	
Starter Circuit Resistance	Yes	
Transmission Oil Pressure	No	Yes
Transmission Oil Temperature	No	Yes
Transmission Oil Filter ΔP	No	Yes
Turbocharger Outlet Pressure	Yes	
Ramp Lowering Solenoid	No	Yes
Ramp Hydraulic Motor	No	Yes

2.4 Omission of DCA Functions

The Individual DCA Descriptions in Appendix B of MIL-T-62314(AT) define the top level functions for all vehicles in a generic class. Consequently, some functions are not applicable to all vehicles in that class. For instance, DCA 4 encompasses both turbocharged and non-turbocharged engines; turbocharger outlet pressure cannot be implemented on the latter. Also, Paragraph 40.1 of STE/ICE Specification MIL-T-62314 states: "The vehicle manufacturer may elect not to include all transducers and test voltages in the DCA." A possible candidate for omission at the DCA is engine oil temperature on a water cooled engine. Some parameters displayed on the operator's instrument panel could also be omitted at the DCA without unduly compromising test effectiveness. Examples are coolant temperature and engine oil pressure. The accuracy of the DCA transducers is such that comparison of VTM readings to the indicator panel readings may show significant differences and may lead the user to question either the vehicle indicators or the VTM. Consequently, it is better to avoid duplication. When the operator has reason to question the vehicle indicators, he can use the VTM to run TM recommended voltage and resistance checks or use the available TK transducers to independently check the questioned vehicle parameter. Another area to consider for omission is the battery electrolyte probes. The probes are valuable in that they provide easy serviceability checks on batteries that are not maintenance free or are located in relatively inaccessible areas prone to inspection oversight as in the M60A1. However, the probes are not applicable to maintenance-free batteries and could judiciously be omitted in installations having convenient access for visual inspection of electrolyte level.

On the other hand, engine speed cannot be omitted as it is an essential VTM input for the major performance tests. A minimum DCA implementation on a vehicle must provide at the DCA connector at least the functions listed in Table 2. The connections for these functions permit measurement of engine power, compression unbalance, engine speed under all conditions, battery voltage, and starter negative cable voltage drop.

Table 2. Minimum DCA Functions

Function	Pins
VTM Power	E, F
Code Resistor	H, J
DCA Indicator	D, F, G
Engine Speed	
DCAs 1 - 9, 13	C, D (Shield E)
DCAs 10 - 12	J, K (Shield L)
Engine Ground	M
Battery Voltage Sense	V, W

This brief discussion is not meant to mandate minimization of DCA functions! Omissions are only permitted with adequate justification that diagnostic capability is not compromised. "Not compromised" means that the DCA function does not apply, it is accessed by some alternate means, or it does not have diagnostic worth for your application.

2.5 Test Point Accessibility for TK Tests

Primary factors leading to poor maintenance are the lack of test point access and difficulty of test. An awareness of available tests, test equipment, testing environment, and a conscious effort to design in accessible test points for both physical and electrical parameters is required. Minor provisions or modifications to your present vehicle design can provide a high life cycle cost return on a relatively small initial investment.

A method of test and accessibility must be considered for all functions omitted, or not available at, the installed DCA. The Test Allocation Matrix (Table 1) could serve as a check list to oversee this task.

Consider the following:

- Provide test plugs for pressure measurements; the two TK pressure transducers (-15 to 25 psi, 1000 psi) have 1/4 - 18 pipe threads. A separately available 10,000 psi transducer has a 37° flare fitting.

- Provide electrical test points.

- If the test point area is difficult to access, consider routing the parameter to a convenient area or test panel having pressure taps and electrical test terminals.

- Provide access to cables and wires for clamp-on Current Probe tests. This is particularly important if you choose not to install the current shunt in your DCA. Break out the individual wires to be tested from multi-wire cables and provide a sufficient length or loop to accept the probe and to minimize the flux field of the adjacent wires. Important areas of attention are battery, starter, and alternator/generator cables.

2.6 Test Limits and Vehicle Constants

STE/ICE performs both static and dynamic tests. The dynamic tests of concern are listed in Table 3. All other tests may be considered as static tests.

Table 3. STE/ICE Dynamic Tests

Test Number	Test Name
12, 13	Power Test
14	Compression Unbalance
19	Ignition Timing
72	Starter Current First Peak
73	Internal Battery Resistance
74	Starter Circuit Resistance
75	Battery Resistance Change

For the dynamic test, STE/ICE operates on both vehicle measurements at the DCA and VTM stored vehicle constants.

For the static tests, test values and limits are typically the same as currently established by engine and vehicle manufacturers and noted in the vehicle TM's. Such values and limits should be reviewed with respect to the operating condition at which the test is to be performed, the absolute test values that define normal operation or a failure, and the measurement accuracy of the STE/ICE tests.

The generation of vehicle constants and test limits is presently performed by the STE/ICE prime contractor for the vehicle manufacturer under the cognizance of TACOM. This capability will eventually be transferred to TACOM and separate guideline documents for the development of test limits and vehicle constants will be prepared.

2.7 Other STE/ICE Requirements

TMs: The vehicle manufacturer must incorporate STE/ICE tests into the vehicle technical manuals. Performance and troubleshooting procedures should make use of tests available in both DCA and TK modes of test. The manufacturer shall also generate the equivalent of a Vehicle Test Card for inclusion in the technical manual. The Vehicle Test Card provides a convenient and comprehensive summary of STE/ICE operation and test values applied to a specific vehicle.

Documentation: The vehicle manufacturer must develop DCA parts lists, schematics, wiring diagrams and harness drawings as required by the vehicle procurement contract.

DCA Harness Check Out: The vehicle manufacturer shall apply the appropriate test procedures to verify that the DCA harness is properly wired and free of errors that could damage the vehicle wiring and components, or the VTM. Recommendations for DCA harness checkout and fault isolation are presented in Chapter 5.

CHAPTER 3

DCA COMPONENTS

3.1 DCA Standard Components

Standard components purchased to specifications and inspected in accordance with their associated Qualtiy Assurance Requirements (QARs) will allow you to meet the functional performance and accuracy requirements of the STE/ICE system as spelled out in STE/ICE Specification MIL-T-62314. Table 4 lists the DCA standard components for which specification drawings have been developed.

Table 4. DCA Standard Components

Component	Specification Army Part Number
Pulse Tachometer, In-Line	12258931-1
Pulse Tachometer, Single-ended	12258931-2
Pressure Transducer (8 Ranges)	12258932
Temperature Sensor, Integral Bridge	12258933
Differential Pressure Switch - Multi-point	12258934
Differential Pressure Switch	12258938
Electrolyte Level Sensor	12258935
Shunt 1000 Amp/100 mV	12258937-1
Shunt 2000 Amp/100 mV	12258937-2
Connectors, Harness Transducer	
Contact, Stamped (Pin and Socket)	12258939
Insulator, Housing, Receptacle	12258940
Connector, Receptacle 54 Pin	12258941
Cap, Dust	12258943

The diagnostic connector (12258941) must be used to interface with STE/ICE and is available from two vendors.

You are urged to utilize the other components listed to derive the benefits of evaluation, review, and experience sponsored by TACOM for most of the components. Further, standardization has inherent benefits such as reduced parts proliferation and established sources of supply.

You are responsible for all quality assurance provisions associated with the purchase and application of the components. Quality Assurance Requirements (QARs) defining uniform inspection and test procedures exist for most of the sensors. QARs have the same drawing number as the DCA standard component.

Experience to date has resulted in the establishment of suppliers for the DCA standard components. It is also anticipated that additions and revisions to the standard component listing and vendor sources are inevitable. Please contact your contracting officer for the revisions to the standard component listing and sources of supply.

The standard DCA components are described in the paragraphs that follow.

3.2 Diesel Engine Speed Transducer

The standard DCA transducer for diesel engine speed* is a pulse tachometer which is simple in design, self generating, and reliable. Similar devices are in production and in use on commercial vehicles. In the DCA tachometer, a rotating disc magnet actuates a reed switch, generating two switch closures (pulses) per revolution of its own shaft. Figure 6 shows the output waveform of the tachometer.

The DCA tachometer is normally mounted at the tachometer takeoff on the engine. For these installations, one pulse per crankshaft revolution is desired. Since two pulses are generated per tachometer shaft revolution, the speed ratio of the takeoff shaft to the crankshaft determines whether a speed reducer is needed. On a four-stroke engine, the takeoff is usually driven by the camshaft which turns at half crankshaft speed. In this case, the tachometer produces the desired one pulse per crankshaft revolution and a speed reducer is not required. Two-stroke engines require the 2:1 speed reducer before the tachometer since the camshaft turns at the same speed as the crankshaft. Some vehicle manufacturers install a 2:1 speed reducer between the tachometer takeoff and the tachometer cable to interface with the standard mechanical tachometer installed on the vehicle instrument panel. On such engines the DCA pulse tachometer should be installed after the speed reducer. If the buildup of components is excessive, a tee reducer having the 2:1 reduction can be substituted for the in-line speed reducer. For these applications the DCA indicator network shown in Figure 9(a) or 9(b) (see paragraph 4.5) directs the VTM to apply the speed conversion constant for one pulse per crankshaft revolution. These networks are used with speed transducers that provide one pulse per two crankshaft revolutions. Such an application exists on a four-stroke engine using a magnetic pickup activated by a cam lobe on the camshaft.

Two configurations of the pulse tachometer are available: an in-line unit and a single ended unit. The in-line tachometer is inserted directly between the standard SAE tachometer drive on the engine and tachometer drive cable. This configuration retains the operation of the mechanical tachometer on the driver's instrumment panel while providing the STE/ICE output. The single ended configuration is used when the mechanical cable drive is not required or when the tee reducer is used. Mount the pulse tachometer at the engine. Installation at the end of a flexible drive cable is discouraged as cable torsion and whip may cause speed and related test results to be erratic.

3.3 Pressure Transducer

The standard DCA pressure transducer is of the diffused piezoresistive strain gage type and is widely used for automotive control and diagnostic functions. It is highly accurate and has a proven record of reliable performance in vehicle environments.

The strain gages that make up the sensor's bridge circuit are diffused directly into a silicon diaphragm using integrated circuit fabrication techniques. The diaphragms are relatively small with high natural frequencies that can withstand the structural vibrations associated with diesel engines.

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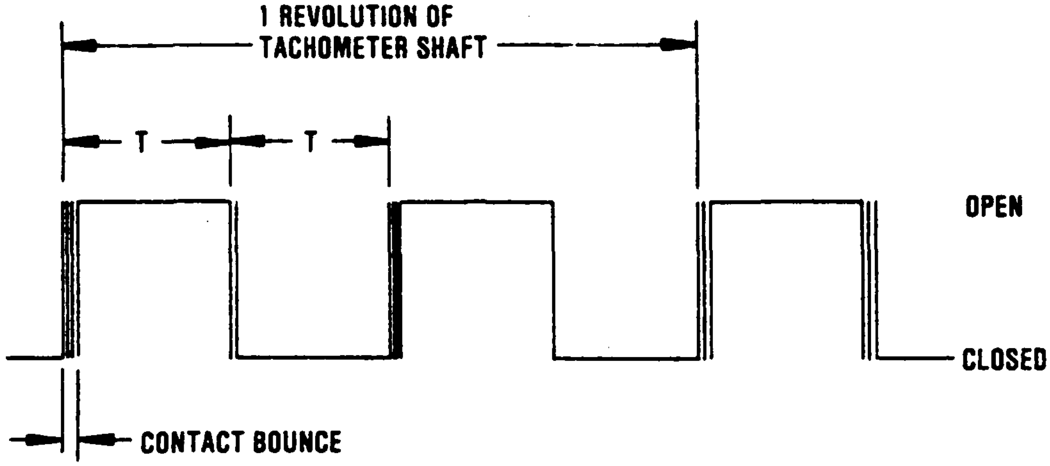
*See Paragraph 4.14 for Spark Ignition Engine Speed Sensing



NOTES:

(1) CONTACT BOUNCE SHALL BE LESS THAN ONE MILLISECOND.

(2) PULSE TIME INTERVAL 'T' MUST BE EQUAL TO OR GREATER THAN FIVE MILLISECONDS AT ALL SPEEDS.

(3) ELECTRICAL NOISE WITH SWITCH OPEN MUST BE LESS THAN ONE VOLT PEAK-TO-PEAK WITH A 20K OHM TERMINATION AT THE DCA CONNECTOR

Figure 6. Pulse Tachometer Output Waveform

Eight pressure ranges are defined on the DCA Pressure Transducer Drawing 12258932. Typical applications are:

-15 psig	Manifold Vacuum, SI Engine
-5 psig	Air Cleaner Pressure Drop
10 psig	Fuel Supply Pressure - SI Engines Air Box Pressure - two stroke CI Engines
25 psig	Turbocharger and Airbox Pressures
30 psig	Fuel Supply Pressure
100 psis	Fuel Supply and Return Pressure
300 psis	Fuel Supply Pressure Transmission Oil Pressure
3000 psis	Hydraulic System Pressures

CAUTION: It may become necessary to install a pressure snubber or other pressure attenuation device between the transducer and the measured parameter due to transient pressure spikes. Pressure spikes are common in fuel injection and hydraulic system lines. The pressure spikes are reflected back to the transducer through the system line, sometimes at a pressure great enough to exceed the proof pressure of the transducer, thereby causing permanent damage. It is suggested that the pressure parameter being measured be thoroughly investigated to eliminate this potential problem.

The accuracy of pressure measurements are enhanced by two system techniques. One, the transducer output is ratiometeric; that is, the output varies as a function of both pressure and excitation voltage. The excitation voltage is measured in the VTM for each test, and a scale factor correction is applied for deviations from the ideal 12 volts. Two, the transducer and system zero offset error is stored during the calibration test and subtracted from subsequent measurements. The zero offset can be measured and stored whenever the sensed media pressure is reduced to 0 psi.

3.4 Temperature Transducer

The standard DCA temperature transducer is a resistive temperature device (RTD) with Wheatstone bridge completion at the sensor. This device exhibits good reliability and is compatible with the VTM differential measurement channels. Temperature detection depends upon the fact that for many materials (platinum, pure nickel, nickel-iron alloy) the resistance varies directly with temperature in a very reproducible way over a useful temperature range. The VTM interface requires that the DCA temperature transducer provide 0 - 100 mV output for a 0 - 300°F input. The temperature transducer output is ratiometric and scale factor corrections are made by the VTM for deviations in excitation voltage. Zero offset corrections for the transducer segment of the measurement chain are not practical since the measured temperatures, and therefore transducer output, will not go to zero when the engine is shut down. However, system accuracy is improved by eliminating the zero offset of the VTM. This is accomplished by installing a shorting switch in the output of the transducer to simulate a zero temperature as described in Paragraph 4.7.

3.5 Differential Pressure Switch

This unit consists of a spring loaded piston that moves as a result of the difference in fluid pressure on either side of the piston. The piston includes a magnetic element that opens a reed switch at a designated differential pressure set point. The Differential Pressure Switch measures clogging of fuel filters and provides a switch output to the VTM. It should be installed across the secondary fuel filter with the high or inlet port side tee'd to the filter inlet and low port tee'd to the filter outlet. Note that the DCA wiring to this transducer must include a 47K ohm resistor across the output wires as described in Paragraph 4.6. The switch is a passive two wire device and does not have a polarity requirement. The set point of the DCA standard ΔP switch, Part 12258938, is specified at 13.5 psid. Additional set points and dash numbers will be specified in the near future.

The magnetically actuated setpoint may be slightly affected if the unit is mounted directly on a large ferrous mass, such as the engine block. Mounting to a nonferrous bracket, or spacing from the ferrous surface may be required. Refer to the drawing for mounting requirements.

3.6 Differential Pressure Switch, Multi-Point

This unit is similar in principle to the above differential pressure switch except three set points and corresponding output voltages are provided. In the Individual DCA Description, this device is applied to oil filters as a simple, reliable and low cost alternative to a "fully analog output" differential pressure transducer. The magnetic piston successively actuates three reed switches connected to a

voltage divider network. With 12 volts (transducer excitation) applied to the network, a stepped voltage proportional to a differential pressure quartile of full scale range is outputted to the VTM.

As an example, the 25 psid unit with a 90 millivolt full scale output will produce the following values:

PSID	SET POINT 1		SET POINT 2		SET POINT 3	
RANGE	PSID	V OUT	PSID	V OUT	PSID	V OUT
0-25	6.25	22.5 MV	12.5	45	18.75	67.5

A pressure drop less than 6.25 psid results in a zero output. When the pressure drop across the filter increases to 6.25 psid, set point 1 is tripped and the VTM senses 22.5 mV as one-quarter of the full scale output and will display 6.25 (psid). Set point 1 indicates that the pressure drop is at least one-quarter, but less than one-half of full scale.

The connector pin functions of this device must be observed. Refer to drawing 12258934 for mounting to a large ferrous surface.

3.7 Current Measurement Transducer

The standard DCA current measurement is a shunt. The shunt is an application of ohm's law; that is, the shunt is a calibrated resistance designed to produce an accurate voltage drop for a specified current range. The shunt should be located in the battery ground cable as illustrated in Figure C-1, Appendix C. Two shunt ranges are specified, 1000 and 2000 amperes. Each is configured for 100 millivolts full scale output. The ampere ratings define nominal values for identification purposes: not constant current application. The shunt physical sizing is based on values for starter peak current, starter cranking current, charging current, and appropriate duty cycle for each. The VTM/shunt channel is capable of measuring a maximum first peak starter current of 1500 and 3000 amperes, respectively. Refer to drawing 12258937 for more details about the shunt's measurement capabilities.

The shunt approach to current measurement is based on simplicity, ruggedness, reliability, long term stability and low cost. Hall effect current measurement sensors for DCA application are under evaluation and may be recommended as an alternative device for the shunt in the near future.

3.8 Electrolyte Level Probe

Battery electrolyte level is sensed with a conductive probe installed at the battery cap/filler hole. The standard battery cap then screws into the electrolyte sensor to provide venting and submersion water proofing. A voltage is seen if the electrolyte level has not receded beyond the "add water" point. STE/ICE accepts a voltage reading of 3 - 20 volts on each electrolyte channel (pins Z, a, b) as a satisfactory electrolyte level. This means that the STE/ICE probe can be located in any but the two outermost cells (i.e. the cell nearest ground and the cell nearest the 24-volt terminal). If less than three probes are installed, the unused channels at the diagnostic connector must be connected to an active electrolyte channel. A 24K ohm resistor must be installed connecting each probe output to ground to prevent erosion of the submerged probe as described in Paragraph 4.8.

3.9 Diagnostic Connector

The diagnostic connector is a wall mounting receptacle with bayonette coupling and fifty-four AWG 16 rear release crimp female contacts. A resilient grommet and short end bell provide a rear seal against the insulation of the individual wires. Wire insulation diameters of 0.064 to 0.130 inch can be sealed. Also, use insert plugs in any unused contact locations to preserve the moisture seal and contact spacing. Provide a chained dust cap (12258943) for this connector.

Two suppliers have been established for the diagnostic connector shown on drawing 12258941; ITT Cannon and Litton Precision Products, International. The connectors from either company are identical with respect to inter-mating with the STE/ICE W1 Cable connector and mounting configuration. Either one can be mounted on the vehicle and will mate with either a Cannon or Litton connector on Cable W1. However, differences exist in the external configuration of the female contact, and therefore in the connector insert configuration that retains them. The contacts are not interchangeable between Litton and Cannon connectors. This means that the harness fabricator must maintain separate part control if connectors are procured from both sources. Also, vehicle drawings and repair instructions must address this difference.

3.10 Harness/Transducer Connectors

The connectors required to mate with the DCA standard sensors are manufactured by ITT Cannon as the "Sure Seal Series" and were developed specifically for automotive applications. Each half consists of a single piece molded body. The receptacle half that mates with the transducers is specified on drawing 12258941. Male and female contacts are specified on drawing 12258939. Note that both male and female contacts are used in the multiple pin receptacles. Environmental sealing is maintained when wiring insulation of 0.100 to 0.147 inch diameter is used.

CHAPTER 4

DCA DESIGN DETAILS

This chapter presents design details relative to installation of the DCA. It addresses many of the questions and problems thus far posed by vehicle manufacturers in addition to providing guidelines for implementing the Diagnostic Connector Assembly and integrating it into the vehicle.

4.1 Overall Harness Layout

In general, the layout of the DCA harness divides into a vehicle chassis segment and an engine segment that normally requires passage through a compartment bulkhead. The chassis portion usually includes the diagnostic connector, battery connections, and other non-engine mounted test points. The engine segment should be connector separable from the remainder of the harness to permit rapid removal of the engine without having to disconnect transducers and electrical test points. The ideal location for the engine harness connector is at the engine compartment bulkhead (see Figure 7).

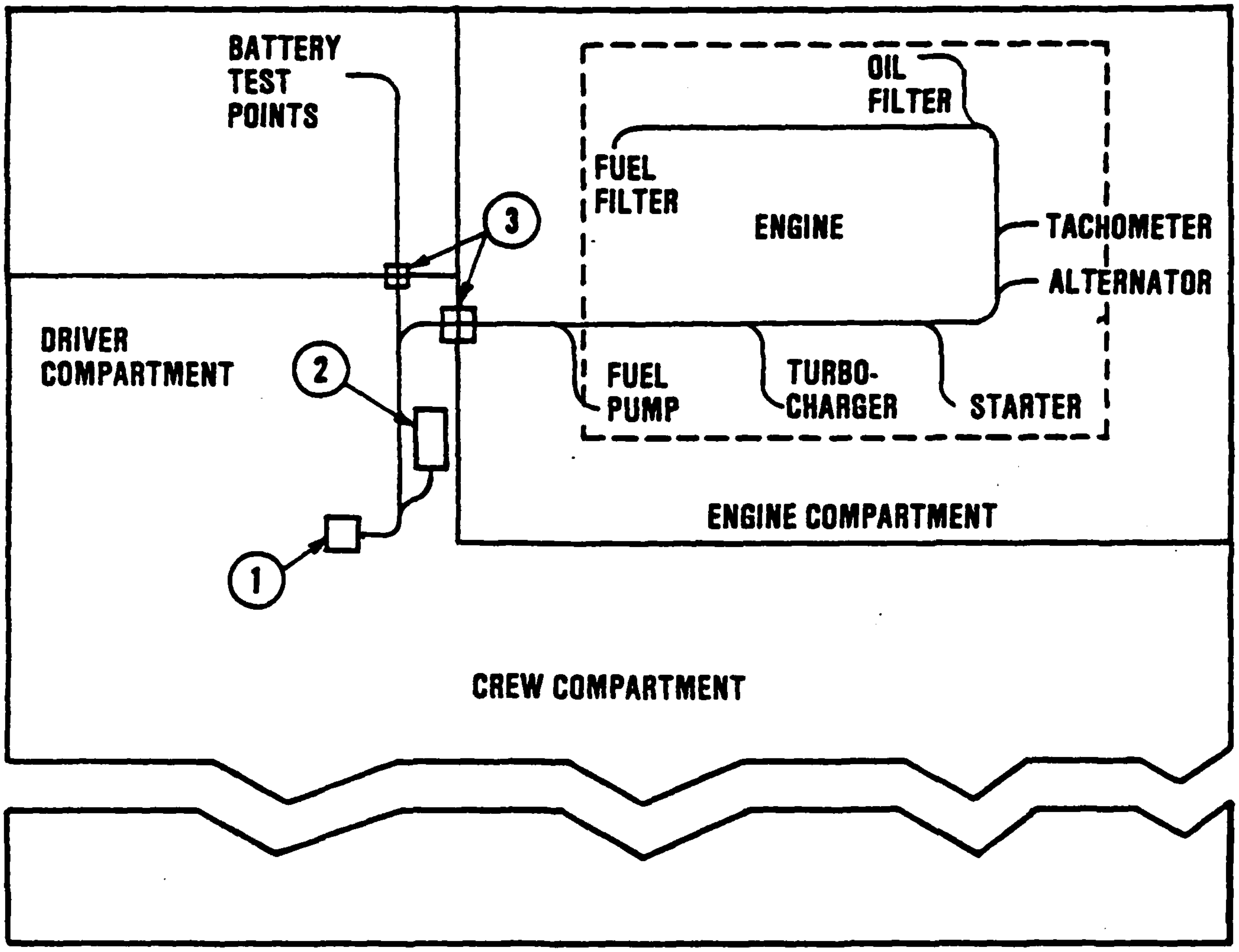
The harness must be routed to minimize damage from exposure to environmental elements, road debris and undercarriage abrasion on wheeled vehicles, excessively hot areas such as exhaust manifold, and areas subject to abuse. The DCA harness must be secured with adequate cable clamps and ties, particularly where the harness or cable weight and vibration could separate the friction mated transducer connectors. Intrinsic safety, particularly with respect to electrical test connections at potentially high current sources, must be considered.

4.2 DCA Connector Location

The diagnostic connector should be located in a relatively clean area protected from the weather, road splash, and accumulation of grease and grime. The preferred location is in the cab or vehicle enclosure near the driver's position. Mount the connector with its major key way upright at the 12 o'clock position. Provide adequate hand room to permit connection of cable W1. The VTM, connected to the diagnostic connector with cable W1, should be capable of being placed within the driver's view and reach. Cable W1 is eight feet long. This placement allows the operator to simultaneously operate the vehicle and the VTM. It also allows the operator to check parameters displayed on the vehicle instrument panel, which is especially useful when these parameters are not tested by the DCA. Install Dust Cap 12258943 to protect the connector when it is not in use.

4.3 No Sensor Measurement Channel Termination

As detailed in Chapter 2, all transducers are test point voltages in the Generic DCA Description may not be included in the DCA harness. For the omitted functions, an alternate "No Sensor" connection eliminates false or erratic VTM readings caused by the open circuits. Such readings may cause the mechanic to believe the vehicle or the STE/ICE is faulty and could lead to unnecessary fault isolation procedures. Pressure, temperature, and current sensors which ordinarily provide a differential output of +/-5 volts or less, shall be replaced by a resistor divider network as shown in Figure 8(A). All omitted transducer outputs may be connected to one



① DCA CONNECTOR
② DCA 'RESISTOR' NETWORK
③ BULKHEAD CONNECTOR

Figure 7. Sample DCA Harness Layout

divider network including those on a second DCA connector. The connection for omission of the fuel filter ΔP function shall be as shown in Figure 8(B). For vehicle test points where a signal in the range of 0-32 volts would normally exist, or if all electrolyte sensors are omitted, a "No Sensor" connection shall be as shown in Figure 8(C). Resistors shall be RNR55 type with +/-1% purchase tolerance. The physical location of the "No Sensor" networks is detailed in Paragraph 4.10.

4.4 Code Resistor

The vehicle code resistor is read by the VTM to select the conversion constants, gains, and filtering preassigned for each DCA class. The code resistor shall be of the RNR55 type with a purchase tolerance of +/-0.5%. Values shall be in accordance with the individual DCA class description of the STE/ICE Specification. The code resistor connects to pins h and j of the diagnostic connector and should be located on the resistor assembly discussed in Paragraph 4.10.

4.5 DCA Indicator

The DCA Indicator is required individually for each DCA installed in the vehicle. It provides vehicle information to the VTM in addition to that provided by the DCA code resistor. For diesel engines, the connection to pin "D" indicates whether vehicle mounted transducers (pressure, temperature, or oil filter ΔP) are powered by the VTM or by the vehicle, and whether the pulse tachometer supplies one pulse per engine revolution, or one pulse per two revolutions. The appropriate resistor networks are shown in Figure 9. Resistors are the RNR55 type with a purchase tolerance of +/-5%. For spark ignition engines, Figures 9(a) and 9(b) are used only to indicate how the DCA transducers are powered; pulse tachometer information is obviously not required since speed is derived from the points opening signal. The physical assembly and location of the networks are detailed in Paragraph 4.10.

4.6 Fuel Filter ΔP Switch Resistor

The fuel filter ΔP switch 12258938 requires that a 47K ohm resistor be installed between pins s and t of the DCA connector. The proper harness connection of this resistor is shown in Appendix C. The resistor is of the RNR55 type with a purchase tolerance of +/-10.0%. The physical location of this resistor is detailed in Paragraph 4.10.

4.7 Temperature Sensor Zero Offset Switch

A zero output from the temperature sensors must be simulated to eliminate the zero offset error in the VTM. Install a shorting switch across the DCA output wires for each temperature sensor. Locate the switch in an accessible place near the diagnostic connector and identify it. A typical connection scheme is shown in Figure 10.

4.8 Electrolyte Probe Trickle Current

It is necessary to maintain the probes at a negative potential to eliminate dissolution in the electrolyte. Install a 24K ohm load resistor between the DCA electrolyte wire (Z, a, b) and battery ground for each electrolyte probe. The current drain will be approximately 1 milliamp from each battery. See Appendix C, Figure C-1, for a connection illustration. The resistors may be grouped in one resistor assembly; see Paragraph 4.10.

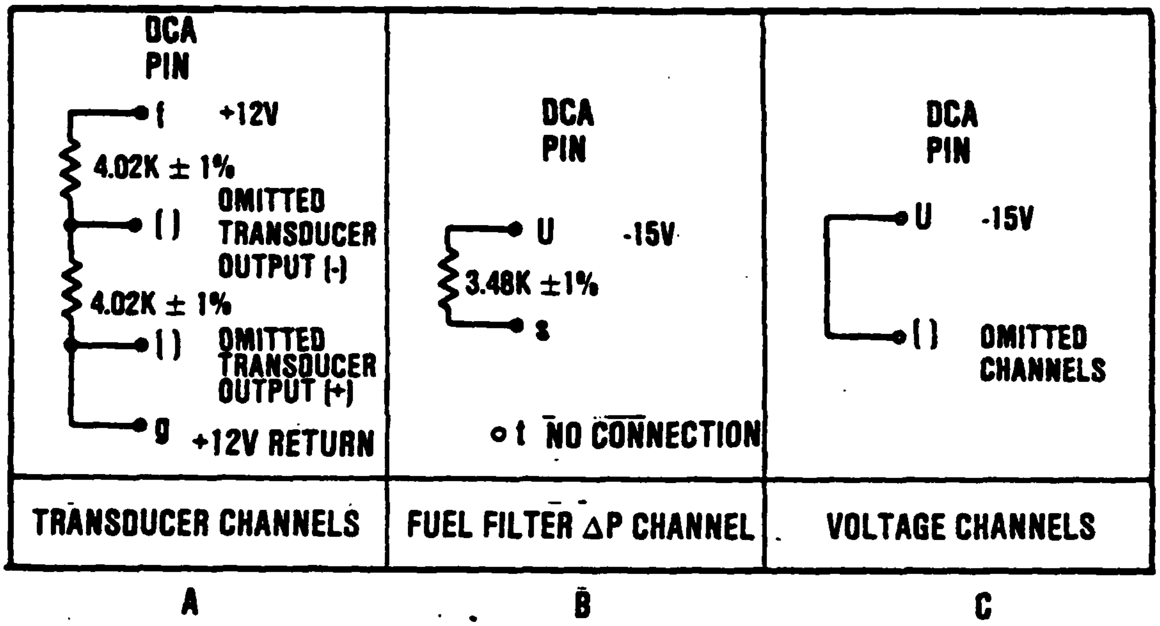


Figure 8. No Sensor Connections

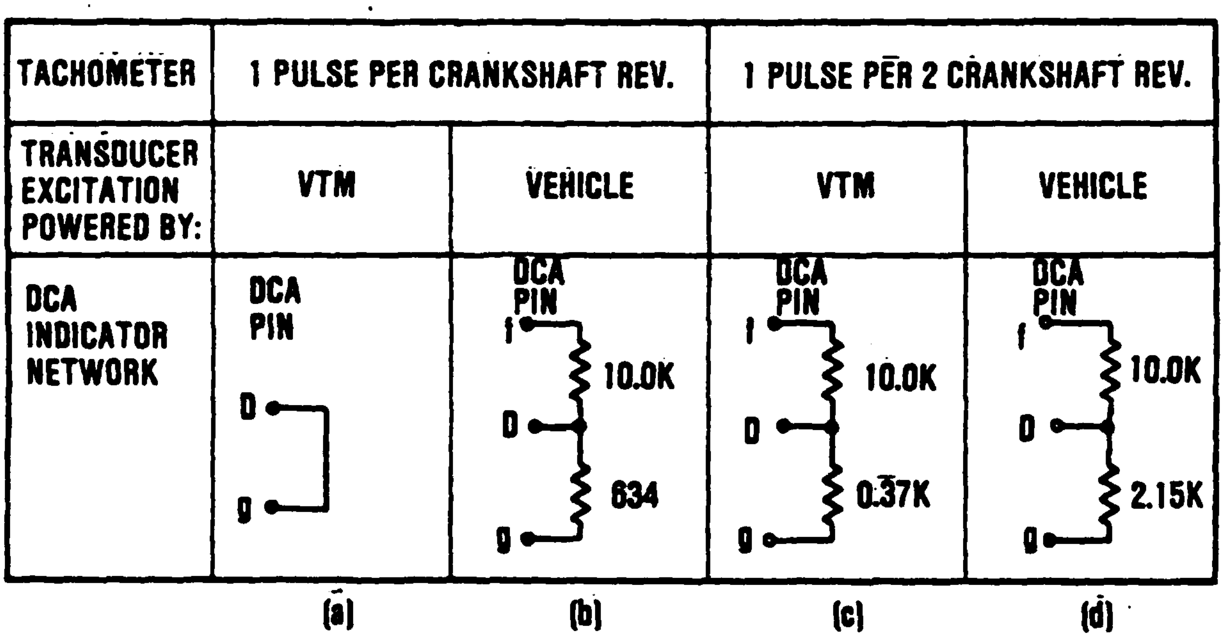


Figure 9. DCA Indicator Networks

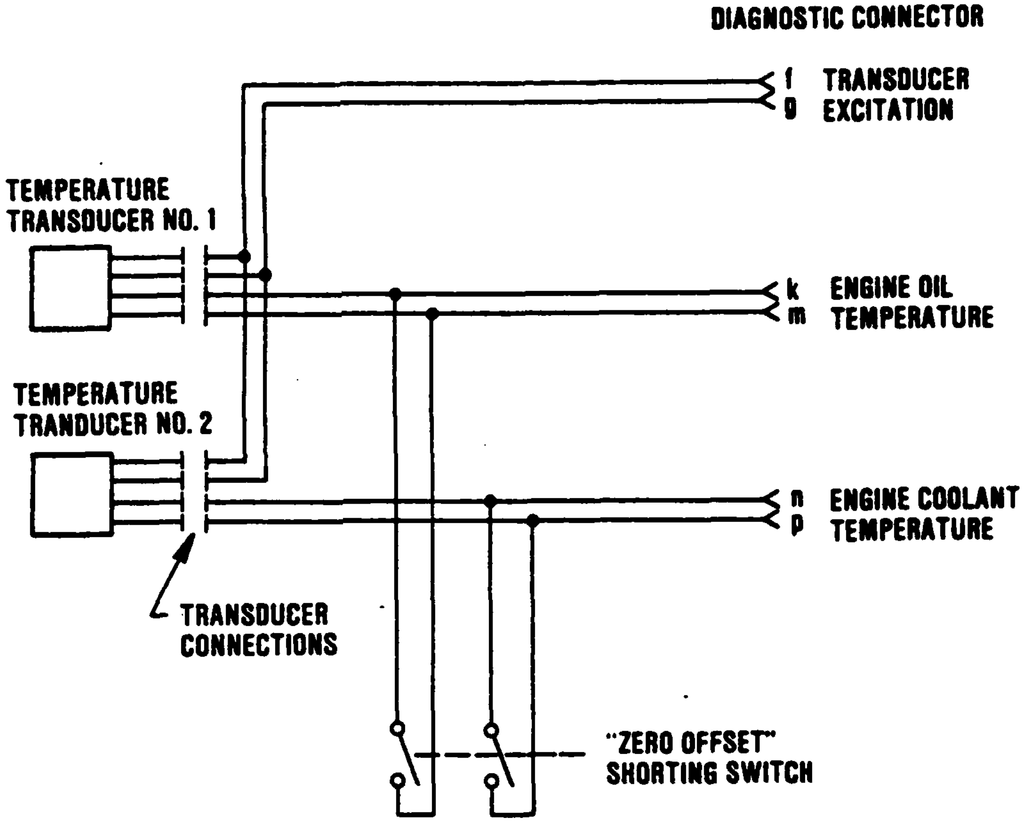


Figure 10. Temperature Sensor Shorting Switch

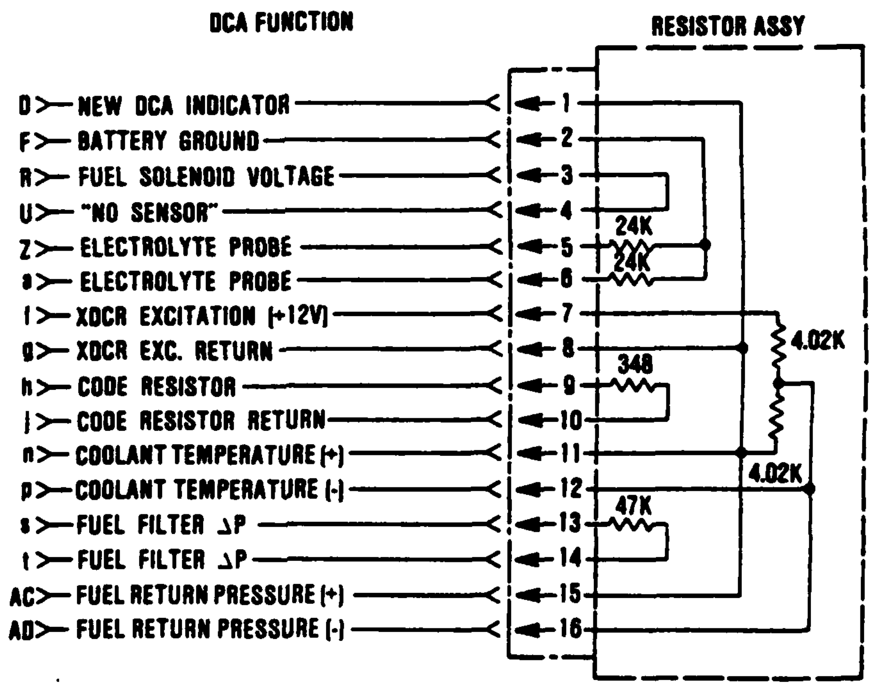


Figure 11. Resistor Assembly Schematic

4.9 Second DCA Connector Wiring Restrictions

When an optional second DCA (normally DCA 13) is implemented on a vehicle, some functions cannot be shared with the primary DCA. The Code Resistor (Pins h, i), DCA Indicator (Pins D, f, g and associated resistors) and transducer excitation (Pins f, g) are required individually at both DCA 13 and the primary connector. These functions cannot be shared between diagnostic connectors.

Other functions such as VTM Power, Engine Speed, Engine Ground, and Battery Voltage Sense may be shared and wired from the primary connector and need not be duplicated. Wiring may be simplified by jumpers across the diagnostic connectors or to a conveniently located terminal junction.

4.10 DCA Harness Resistor Assembly

Mount the DCA resistors and resistor networks on a separate component board (terminal or printed circuit) and mount the board in a well protected area or enclosure to provide protection from the environment. Insure access to the board for quick fault isolation when problems do occur. The board may be hard wired to the diagnostic harness. However, a separate module with connector disconnect(s) is recommended.

The "No Sensor Connector for the 32 Volt Channels" and "DCA Indication" are merely wire jumpers that can be made at the Diagnostic Connector. However, if many 32-volt connections are omitted on the vehicle, or if you anticipate electrical test point changes, it would be advisable to also locate these connections at the resistor board assembly.

A typical resistor assembly wiring schematic is shown in Figure 11. The schematic discloses the following characteristics of the DCA installation:

(1) Tachometer output is 1 pulse per revolution of the engine crankshaft.

(2) DCA transducers are excited (powered) from the VTM.

(3) Fuel solenoid voltage connection is omitted.

(4) Electrolyte trickle current resistors are installed in resistor assembly and connect to battery ground.

(5) Coolant temperature and fuel return pressure transducers are omitted.

(6) Code resistor, 348 ohms, identifies Generic DCA 6.

(7) 47K ohm resistor applied across contacts of Fuel Filter ΔP switch.

4.11 Vehicle Powered Transducers

In the design of a new vehicle, it may be possible to derive the required diagnostic signals from transducers or sending units installed for operational control or for the driver's instrument panel.

The signal output to the VTM of such sensors must meet the accuracy and electrical interface requirements of the STE/ICE system. Refer to the STE/ICE Specification, the Individual DCA Description and the specifications for the DCA Standard Components to the extract the requirements for signal conditioning. Also refer to Table 5, which defines the general VTM input characteristics for the measurement channels.

If the transducers replacing the temperature, pressure, or oil filter ΔP transducers are vehicle powered, be sure to use the proper DCA Indicator (Figure 9(b) or 9(d)) to signal that condition to the VTM.

4.12 VTM General Input Characteristics

Table 5 summarizes the VTM input characteristics by DCA input pin numbers. Note under "Comments" that the full scale range and bandwidth value for each channel are programmed into the VTM according to each DCA requirement. Consult the STE/ICE contractor or TACOM DRSTA-RGD if you wish to implement tests having input signals that differ from those shown on the DCA description to determine compatibility with the assigned signal processing in the VTM.

4.13 Diesel Engine Cranking Tests

Several STE/ICE tests are performed under engine cranking conditions. These include Compression Unbalance, Starter Current First Peak, Battery Resistance Change, and other battery starter based tests. The engine must not start. Many diesel engine installations have a manually controlled fuel shutoff that will inhibit starting when the engine is cranked. If the fuel shutoff solenoid on your vehicle is automatically actuated through the engine electrical power switch, you must provide an alternate means to inhibit starting for performance of the cranking tests.

4.14 Spark Ignition Engine Speed Sensing

For SI engines, the speed signal is sensed from the coil primary voltage waveform. The signal can be obtained from either a standard breaker-point type or a solid state saturated transistor type ignition system. The vehicle electrical system may be 12 or 24 volts. Figure 12 depicts a typical primary voltage waveform that will interface with STE/ICE. Note that the saturation voltage cannot exceed 0.75 volts. DCA wiring connections are shown in Appendix C, Figure C-2.

During Compression Unbalance, the STE/ICE ignition interrupt feature disables the spark by limiting the collapse of the coil primary current. By limiting the change in the primary current when the points open or when the transistor turns off, spark ignition is prevented while still providing a speed signal. For power test, the ignition interrupt loads the engine on the M151 and the M880 by allowing only every fifth cylinder to fire. Ignition systems other than those on the M151 or M880 have to be evaluated on an individual basis to determine whether the STE/ICE ignition interrupt feature is applicable.

4.15 Magnetic Pickup Speed Sensor Circuits

For some installations, it may be convenient to use a magnetic pickup rather than the standard DCA Pulse Tachometer. The magnetic pickup may sense a cam lobe, gear teeth, or other mechanical motion that correlates to diesel engine speed. The

Table 5. General VTM Input Characteristics

DCA Input Pin Numbers	Polarity	Type of Input	Maximum Input Voltage	Input Resistance	Maximum Input Bias Current	Comments
L N	+ +	Single-ended with respect to Batt Neg Terminal (W)	±35 Volts	35K Ohms	150 Nanoamps	1. AC, DC, or Frequency measured at these inputs. 2. Full scale ranges: ±35, 3.5, 1.16$\overline{7}$ and 0.583 volts. 3. Bandwidths: 6,60, 600, 6 kHz. 4. Assignments vary with specific DCA's.
O R S T	+ + + +	Single-ended with respect to engine ground (M)				
V W	+ -	Differential				
Z a b	+ + +	Single-ended with respect to engine ground (M)				
k m n p u v w x y z AA AB AC AD X Y	+ - + - + - + - + - + - + - + -	Differential	±5V Differential ±5V at either input with respect to ground	5 meg ohms at either input or differential	1 microamp	1. AC, DC, or frequency may be measured at these inputs. 2. Full scale voltage ranges: ±5, 0.5, 0.1667, and 0.0833 volts. 3. Bandwidths: 6, 60, 600, 6 kHz. 4. Assignments vary with specific DCA's.
c d	+ RTN	Pulse Tach	±12 Volts	1.5K ohms pull-up Resistor to +5 VCD		Max Input Frequency: 100 Hz

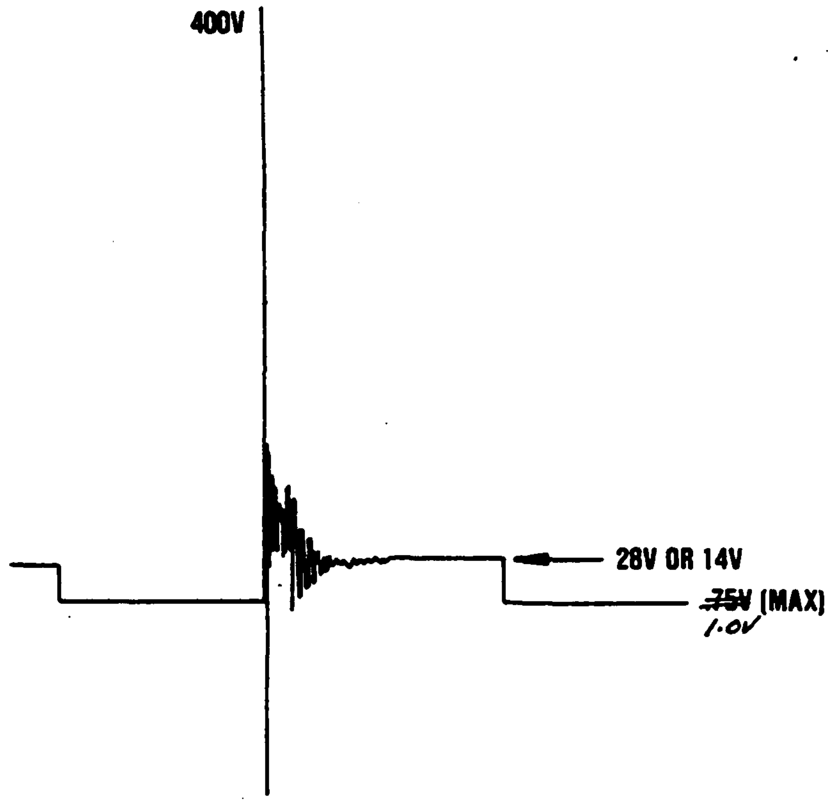
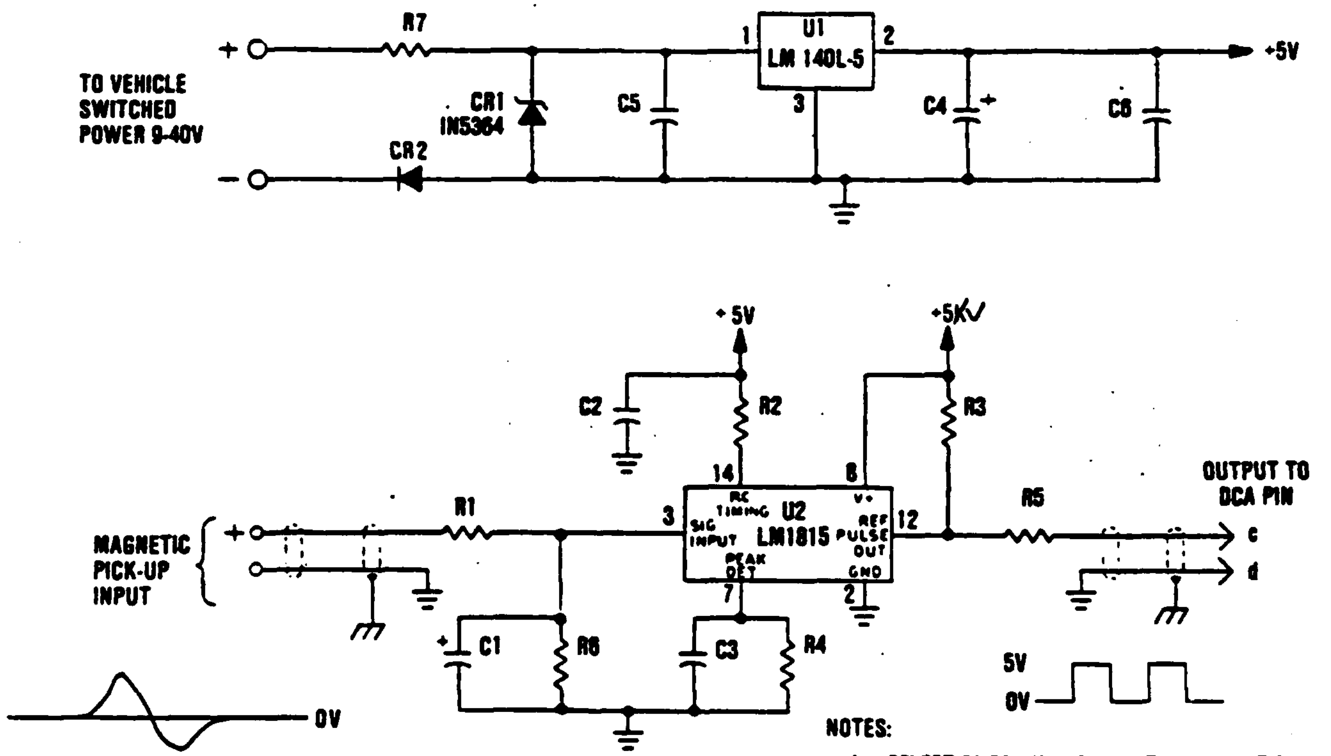


Figure 12. Primary Voltage Waveform

output must be conditioned (squared) to produce a waveform compatible with the tachometer signal requirements shown in Figure 6. Magnetic pickup applications generating multiple pulses per crankshaft revolution can be handled by adding a divide by N circuit, where N is the number of pulses generated by the magnetic pickup for each crankshaft revolution.

Figure 13 shows a sample circuit that detects the zero crossing of a magnetic sensor output and generates a square pulse for each crossing. This circuit may be applied to a magnetic pickup sensing the engine cam lobe. For a four-stroke engine, the camshaft rotates once for two rotations of the crankshaft. It follows that the circuit will output one square pulse for every two crankshaft rotations. Use the DCA Indicator networks of Figure 9(c) or 9(d) to identify the pulse-speed relationship to the VTM.

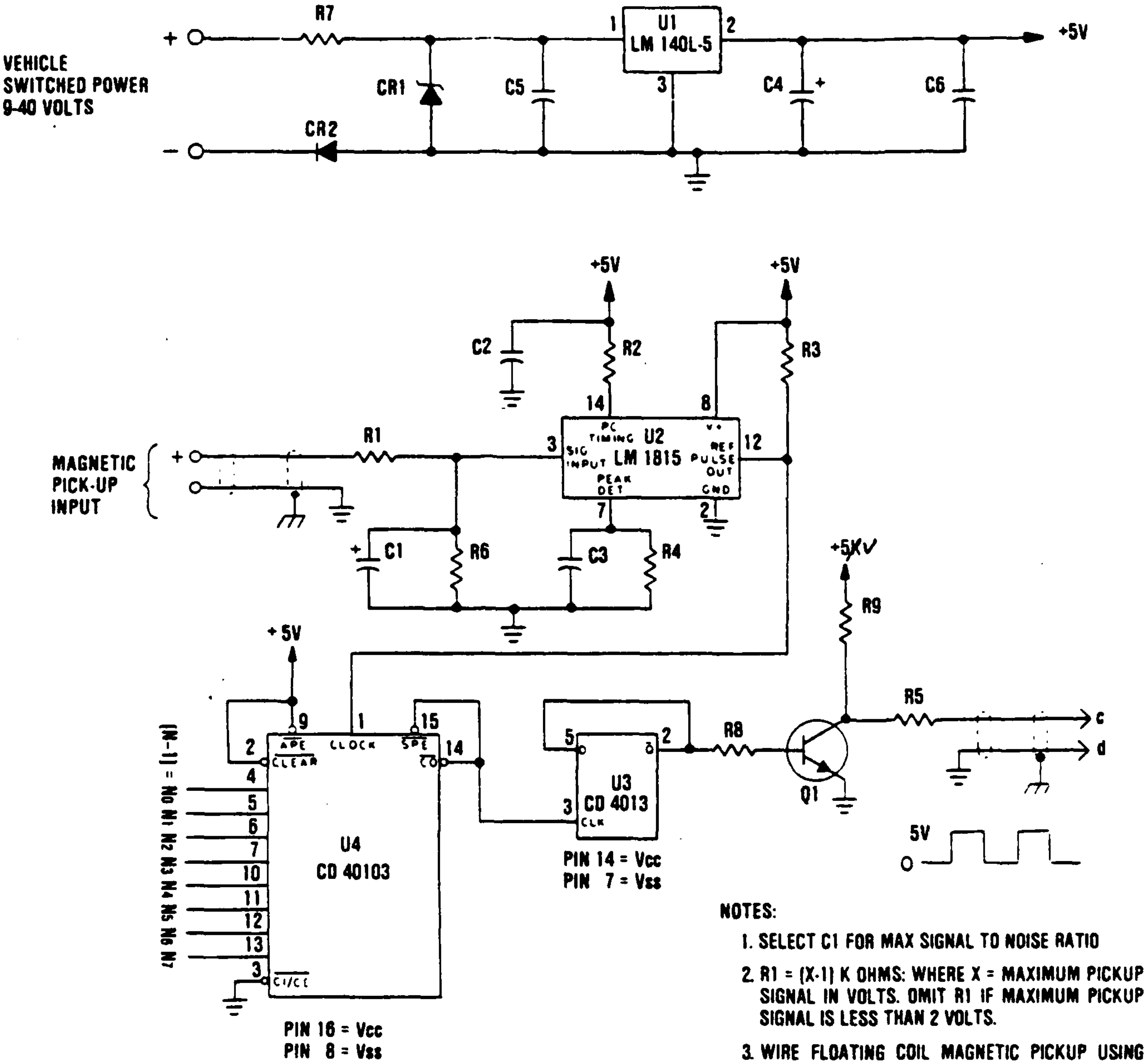
Apply the circuit in Figure 14 to process sensed inputs that are multiples of crankshaft speed, such as ring gear teeth. The output of the front end of the circuit, which is identical to the squaring circuit of Figure 13, is fed into a frequency divider. Set the binary word $N_7\ N_6\ N_5\ N_4\ N_3\ N_2\ N_1\ N_0$ to the binary equivalent for N-1, where N is the number of sensed pulses (or teeth) relative to each crankshaft revolution. The circuit as shown will output one pulse for two crankshaft revolutions. Use the DCA Indicator network shown in Figure 9(c) or 9(d) to identify the final pulse-speed relationship. The circuits of Figures 13 and 14 will accept up to 256 magnetic pickup pulses per revolution at crankshaft speeds up to 5000 RPM.



NOTES:

1. SELECT C1 FOR MAX SIGNAL TO NOISE RATIO
2. R1 = (X-1) K OHMS; WHERE X = MAXIMUM PICKUP SIGNAL IN VOLTS. OMIT R1 IF MAXIMUM PICKUP SIGNAL IS LESS THAN 2 VOLTS.
3. WIRE FLOATING COIL MAGNETIC PICKUP USING SHIELDED TWISTED PAIR CABLE.
4. 100 mV MINIMUM REQUIRED AT U2 PIN 3.
5. INSTRUMENTATION GROUND:
6. VEHICLE CHASSIS GROUND:
7. CONNECT TO VEHICLE SWITCHED POWER: 9-40V

Figure 13. Magnetic Pickup Squaring Circuit



NOTES:

1. SELECT C1 FOR MAX SIGNAL TO NOISE RATIO
2. R1 = (X-1) K OHMS: WHERE X = MAXIMUM PICKUP SIGNAL IN VOLTS. OMIT R1 IF MAXIMUM PICKUP SIGNAL IS LESS THAN 2 VOLTS.
3. WIRE FLOATING COIL MAGNETIC PICKUP USING SHIELDED TWISTED PAIR CABLE.
4. 100mV MINIMUM REQUIRED AT U2 PIN 3.
5. INSTRUMENTATION GROUND:
6. VEHICLE CHASSIS GROUND:
7. CONNECT TO VEHICLE SWITCHED POWER: 9-40V.
8. CONNECT U3 PINS 4, 6, 8, 9, 10, 11 TO INSTRUMENTATION GROUND.
9. AT U4, N0 THROUGH N_7: ~~15V~~ +5V = 1
GND = 0

Figure 14. Frequency Divider

4.16 Differential Pressure Sensor Applications

Detection of filter clogging is measured in terms of differential pressure, i.e., pressure drop across the filter assembly. To conform to the generic DCA descriptions use the following sensors:

Fuel Filter: Differential Pressure Switch (12258938). This unit is a normally closed switch that opens at specified differential pressure.

Oil Filter: Differential Pressure Switch, Multi-point (12258934). This unit is powered from the VTM and provides three stepped output voltages relative to degree of clogging.

Air Cleaner: Pressure Tranducer (12258932-2). This unit measures up to 5 psi vacuum referenced to ambient air pressure.

4.17 Pressure Transient Snubber

Be aware that transient pressure spikes commonly exist in fuel and hydraulic systems and can permanently damage the installed pressure transducers. Transients of 5 to 10 times normal pressures are typical. Also, backfiring in spark ignition engines creates high positive pressures in the intake manifold. Thoroughly investigate pressures that could exhibit transient pulses to determine the transient pressure content. Suppress the transients such that the maximum pressure applied to the installed tranducer is less than the proof pressure. A snubber consisting of a porous sintered metal element can be used as a pressure transient suppressor. Its effectiveness relies on the:

- o flow rate through the snubber element versus time duration of the pressure transient, and
- o volume and compliance of the space between the snubber element and transducer diaphragm.

The sintered metal elements can be obtained in various sizes and porosity or as snubber fittings. An example is the TK snubber 12258881. However, other configurations of snubbers and methods of eliminating or suppressing excessive pressure transient spikes may be used.

CAUTION: Evaluate the location and buildup of components. Avoid extension of hardware susceptible to vibration failure or accidental damage.

4.18 Vehicle Connections

Specific information and typical examples of vehicle connections for the DCA connector pins are given in Appendix C.

4.19 Wire Considerations

The voltage and current requirements for the DCA wiring are relatively low. Vehicle steady state voltages are generally less than 30V and the VTM will draw 3 amps maximum. As a result, wire size selection is more a function of physical strength, particularly where individual or several wires are broken out of the main harness to transducers and vehicle electrical test points. Also, the use of

ruggedized connectors to survive the vehicular environment forces selection of larger wire sizes than would otherwise be electrically adequate.

The following factors should be considered for wire selection:

- o <u>Diagnostic Connectors</u>: Acceptable wire gage size for the crimp contacts (AWG 16-20) and insulation diameter to achieve moisture sealing in the rear grommet. Manufacturer recommends insulation diameter of 0.064 to 0.130 inch.

- o <u>Transducer Sure-Seal Connectors</u>: Acceptable wire gage size for the contacts (AWG 14-18) and insulation diameter to provide waterproof sealing in the elastomer body (0.100 to 0.147 inch). Use of insulation diameter less than 0.100 inch will compromise the waterproof capability and may require the addition of a sealing boot or a buildup of the wire insulation diameter where it enters the connector.

Overall wiring requirements, including harness, cable, connector, and termination identifications, must be in accordance with wiring requirements specified for the vehicle.

4.20 Shielding Requirements

The requirement for shielding of low level transducer signals is defined in the STE/ICE specification (MIL-T-62314, APPENDIX B, Paragraphs 40.8, 40.9) as a function of transducer output and noise frequency. The maximum allowable peak-to-peak differential noise voltage over the applicable frequency range of DC to 1 megahertz is given by:

$$\text{Noise p-p} = \frac{10\ (\text{full scale output in mV})\ (\text{noise freq} + 10^3\ \text{Hz})}{(\text{noise freq} + 10^7\ \text{Hz})}$$

The noise voltage should be measured across the vehicle mounted DCA connector output pins for each transducer. Most noise problems can be minimized by applying normal suppression methods to the vehicle components, by physical separation of the diagnostic harness transducer wires from noise sources, and by routing the harness in physically protected areas of the vehicle. If the noise level is still above the maximum allowable value, then shielding will be required to further suppress the noise signal. As a minimum, shielding is recommended for the pulse tachometer, VTM power leads (pins E and F) and the points signal.

Use twisted pair shielded cable and float the shield at the vehicle test point. Connect the other end of the shield to vehicle chassis ground near the diagnostic connector.

If shielding is required for the remaining transducers, it should be installed around the transducer wiring, terminating near the diagnostic connector as shown in Appendix C, Figure C-9. The shielding should be installed up to the transducer connector. Where the transducer wiring is bundled as it approaches the diagnostic connector, the wires may be grouped within one overall shield. The shield should be "grounded" only to a chassis ground on the vehicle at the diagnostic connector.

The shield should float at the transducer end of the harness and should be taped or insulated to eliminate multiple grounding points along the harness wiring.

CAUTION: SHIELDS SHALL NOT BE CONNECTED TO THE DCA CONNECTOR PINS.

4.21 Safety

This Design Guide is an advisory document. All designs and implementations of the Diagnostic Connector Assembly and its components must meet vehicle safety requirements.

CHAPTER 5

DCA HARNESS CHECKOUT AND FAULT ISOLATION

Vehicle DCA harnesses must be tested prior to interfacing with a VTM to insure that wiring and connections are free of errors. Miswiring of conductors from high current sources could damage the DCA or the VTM.

The basic equipment for detecting and isolating faults in the harness are:

Multimeter
DCA Breakout Box*
DCA Tester*

As a minimum, evaluate the signals at the diagnostic connector using a multimeter. Run the vehicle through the basic operations that activate the measurement channels. Look for reasonableness of signal levels and test for voltage on grounds, shields, and unused pins.

Additional fault isolation capability is provided by the DCA Breakout Box, Figure 15. This unit provides a test jack and fuse for each of the fifty-four DCA wires. It can be interconnected between the DCA and a VTM or DCA tester. The test jacks provide a convenient access for a multimeter or other laboratory test equipment. The DCA Tester, Figure 16, is an automated unit that evaluates specific DCA pins. It tests for over-voltage conditions on the 5 volt channels, and voltages or grounds on shields and returns that should be isolated. The DCA Tester checks only for wiring errors that may damage the VTM. No tests are performed on the thirty-two volt channels because any vehicle voltage is acceptable on those lines (i.e., would not damage the VTM). A DCA Tester Manual describes the Tester and its use.

A general procedure for checkout and isolation of DCA harness faults is illustrated in Figure 17. Actual checkout procedures implemented are expected to include greater testing detail and definitive measurement values.

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*Special test equipment developed by STE/ICE prime contractor.

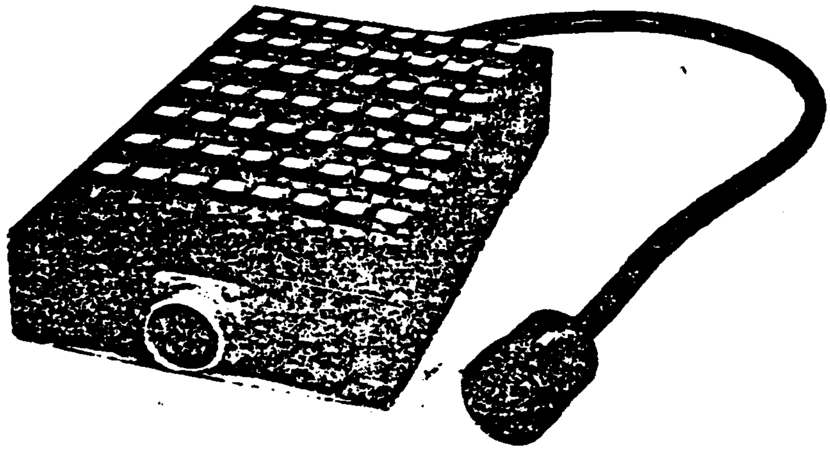

Figure 15. DCA Breakout Box

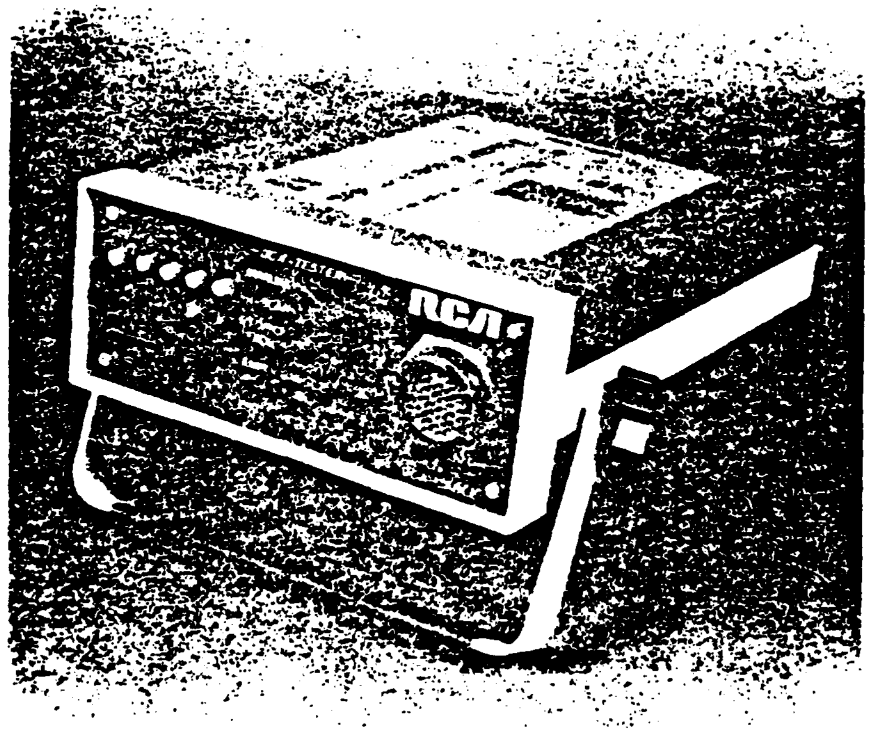

Figure 16. DCA Tester

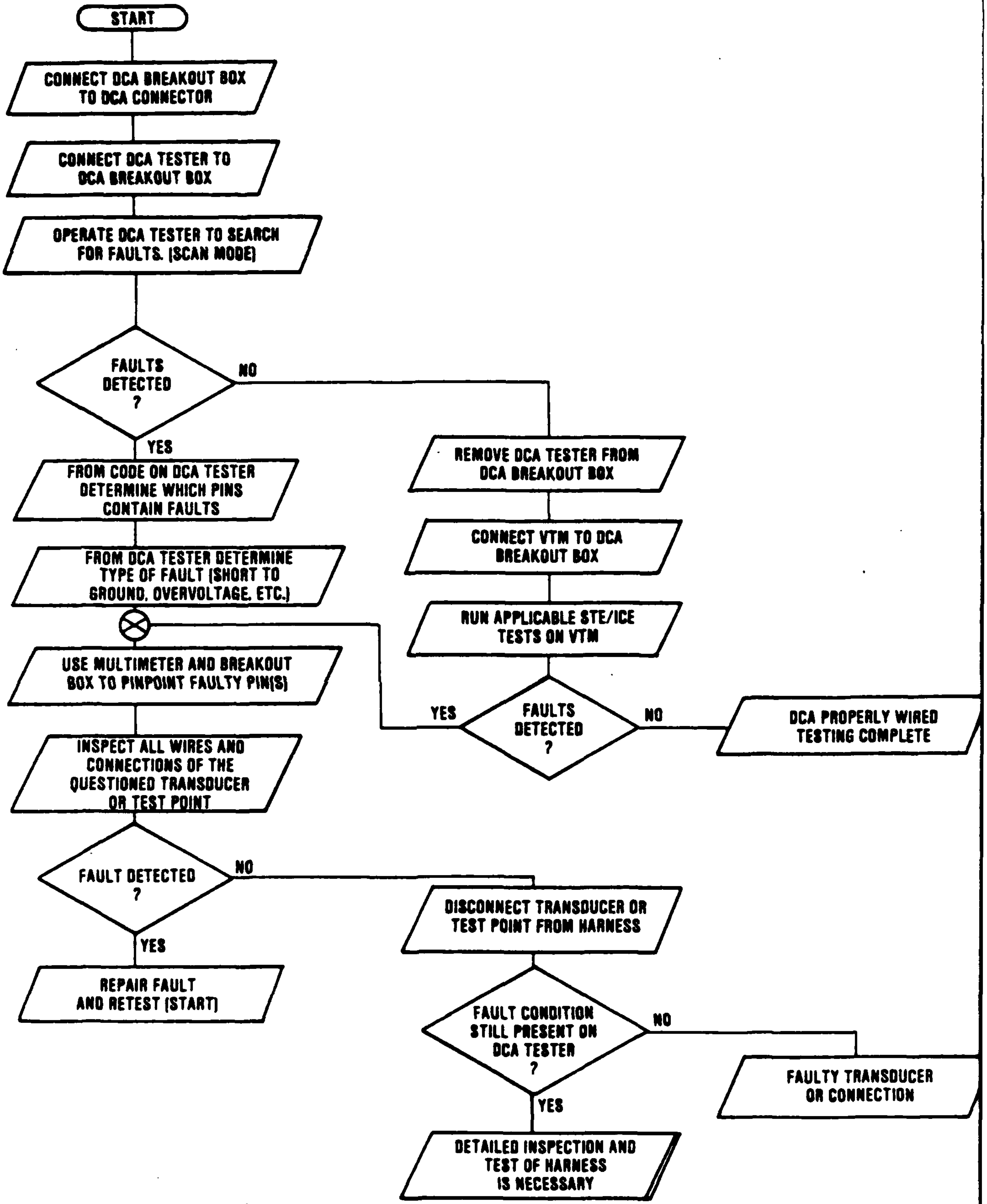

Figure 17. DCA Harness Fault Isolation Flowchart

APPENDIX A

DCA GENERIC CLASS INFORMATION

This appendix provides guidelines for selecting the DCA class for a vehicle.

Table A-1, extracted from MIL-T-62314, provides basic vehicle and engine descriptions by Generic Class and identifies the Table Number in the STE/ICE Specification, MIL-T-62314, for the Individual DCA Description for that class.

Table A-2 shows the application of military vehicles to the DCA classes. The vehicle type and engine list illustrates class distinctions by the assignments made at this writing. The Vehicle Identification Code (VID) is included as a point of information. Note that several VID's can be associated with the same basic engine. This results from variations in the rotary moments of inertia (different flywheels, accessories, etc.) and sometimes differences in starter circuit resistance. Since STE/ICE is being applied to an increasing number of vehicle types, Table A-2 should be viewed as illustrative rather than a complete list of vehicle applications.

In Tables A-3 through A-5, Individual DCA descriptions have been reproduced from MIL-T-62314 to provide a handy reference in this document of DCA examples for diesel engines, gasoline engines, and the optional second DCA 13. Additional information and illustrations for the vehicle connections stated are contained in Appendix C.

Tables

Table A1. DCA General Classes

DCA Class Number	General Class of Vehicles	Engine Types	Table No.
1	Vehicles with medium sized diesel engines	Turbocharged and non-turbocharged engines with single-plunger distributor type fuel systems and turbocharged engines with unit injector fuel systems	4
2		Non-turbocharged engines with unit injector fuel systems	5
3		Cummins engines with PT type of fuel system (turbocharged or not)	6
4		Caterpillar and Mack engines with multiple plunger type fuel systems (turbocharged or not)	7
5	Vehicles with large diesel engines	Turbocharged and non-turbocharged engines with single-plunger distributor type fuel systems and multiple air cleaners and turbo-charges	8
6		Same as Type 1 above except larger engines	9
7		Same as Type 2 above except larger engines	10
8		Same as Type 3 above except larger engines	11
9		Same as Type 4 above except larger engines	12
10	Vehicles with spark ignition engines	Four cycle, four cylinder engines such as M151A2 with standard 24-volt military ignition system	13
11		Four cycle, six cylinder engines with standard 24-volt ignition system or Chrysler type of solid state ignition system similar to that in M880	14
12		Four cycle, six cylinder engines with standard 24-volt ignition system or Chrysler type of solid state ignition system similar to that in M880	15

Table A1. DCA General Classes (Continued)

DCA Class Number	General Class of Vehicles	Engine Types	Table No.
13	Optional Second DCA Connector	Those vehicles with more test points than can be handled with one DCA connector. Provides additional voltage, temperature, and pressure-test points.	16
14	Reserved		

Table A-2. Vehicles/Engines Serviced by STE/ICE

DCA Class	Vehicles		Engine	VID
1	M35A2	2-1/2 Ton Truck	Continental LD(T)-465	2
	M44A2	2-1/2 Ton Truck	Continental LD(T)-465	2
	M551	Armored Recon Airborne Assault Vehicle	Detroit Diesel 6V-53T	12
2	M113A1	Armored Personnel Carrier	Detroit Diesel 6V-53	3
	M561	1-1/4 Ton Truck	Detroit Diesel 3-53	9
3	M809	5 Ton Truck 6 x 6	Cummins NHC-250	6
	*M915	10 Ton Truck Tractor	Cummins NHC-250	15
	*LVTP7A1	USMC Amphib. Assault Veh.	Cummins VT-903	13
	*M2	Infantry Fighting Veh.	Cummins VT-903	16
	*M3	Calvary Fighting Veh.	Cummins VT-903	16
	*MLRS	Rocket System Vehicle	Cummins VT-903	--
4				
5	M60A1	Main Battle Tank	Continental AVDS-1790	4
6	M107	Self-Propelled Field Artillery Gun	Detroit Diesel 8V-71T	10
	M109	Self-Propelled Medium Howitzer	Detroit Diesel 8V-71T	11
	*M110	Self-Propelled Heavy Howitzer	Detroit Diesel 8V-71T	10
	M578	Field Tracked Light Armored Recovery Veh.	Detroit Diesel 8V-71T	10
7	LVTP7	USMC Personnel Carrier	Detroit Diesel 8V-53T	14
8	M123A1C	10 Ton Truck 6 x 6	Cummins V8-300	7
9	M520	10 Ton Cargo Truck (GOER)	Caterpillar D333C	8
	*M1001	10 Ton Wrecker 8 x 8	M.A.N. D2840MF	17
	*M1002	10 Ton Wrecker 8 x 8	M.A.N. D2840MF	17

* DCAs standard or planned for these vehicles.

Table A-2. Vehicles/Engines Serviced by STE/ICE (Continued)

DCA Class	Vehicles		Engine	VID
10	M151A2	1/4 Ton Truck (Jeep)	Army L141	1
11				
12	M880	1-1/4 Ton Truck, Comm.	Chrysler 318	5
13	*LVTP7A1 *M2 *M3 *MLRS	USMC Amphib. Assault Veh. Infantry Fighting Vehicle Cavalry Fighting Vehicle Rocket System Vehicle	Cummins VT-903 Cummins VT-903 Cummins VT-903 Cummins VT-903	13 16 16 --
14		Reserved		

* DCAs standard or planned for these vehicles.

Table A3. DCA 2 Nonturbocharged Diesel Engines with Unit Injectors

Pin No. (1)	Function	Vehicle Connection	Signal
A	N.C. (4)		
B	N.C. (4)		
C	N.C. (4)		
D	New DCA Indicator		
E	Power (+)	Battery Positive Terminal	Power drawn by VTM
F	Power (-)	Chassis Ground at Battery	9-32 VDC 3A Max
G	N.C. (4)		
H	N.C. (4)		
J	N.C. (4)		
K	N.C. (4)		
L	N.C. (4)		
M	Engine Ground	Engine Ground at Starter	±2 VDC w.r. W
N	Alt/Gen Out	Alt/Gen Positive Terminal	0-32 VDC w.r. W
O	Alt/Gen Field	Alt/Gen Field Positive Terminal	0-32 VDC w.r. M
P	Alt/Gen Ground	Alt/Gen Ground	±2 VDC w.r. W
R	Fuel Solenoid Volts	Fuel Solenoid Positive Terminal	0-32 VDC w.r.M
S	Starter Solenoid Volts	Starter Solenoid Positive Terminal	0-32 VDC w.r.M
T	Starter Volts	Starter Positive Terminal	0-32 VDC w.r.W
U	"No Sensor"	Unused DCA Channels	-15V source
V	Battery (+)	Battery Positive Terminal	10-32 VDC
W	Battery (-)	Battery Negative Terminal	
X	Battery Shunt (+)	Current Shunt in	100 mV/1000 A ±3% Reading
Y	Battery Shunt (-)	Negative Battery Cable	Max CMV ±0.5V
Z	Electrolyte No. 1	Battery No. 1	3 VDC Min - 20 VDC Max
a	Electrolyte No. 2	Battery No. 2 or Pin Z	(Lead Cell Probe)
b	Electrolyte No. 3	Battery No. 3 or Pin Z	
c	Pulse Tach	Reed Switch Type	1 pulse/eng. rev(5)
d	Pulse Tach Return	Contact Bounce 1 ms 50-5000 RPM	Max Noise 1V p-p
e	Pulse Tach Shield		
f	XDCR Excitation	Pressure Transducer	+12V source
g	XDCR Excitation Return	Excitation	
h	Code Resistor	61.9 ohms ±0.5%(3)	
j	Code Res Return		
k	Engine Oil Temp	Transducer (+)	100 mV/300° F ±1.5% F.S.
m		Transducer (-)	
n	Coolant Temp	Transducer (+)	100 mV/300° F ±1.5% F.S.
p		Transducer (-)	
q	N.C.(4)		
r	N.C.(4)		

Table A3. DCA 2 Nonturbocharged Diesel Engines with Unit Injectors (Continued)

Pin No. (1)	Function	Vehicle Connection	Signal
s	Fuel Filter ΔP	Pressure switch (+)	Switch closure: Low ΔP <1.0 Ohm.
t		Pressure switch (-)	High ΔP = 47K Ohms $\pm 10\%$
u	Fuel Supply Pressure	Pressure XDCR (+)	90 mV/100 PSI(2)
v		Pressure XDCR (-)	$\pm 2\%$ Reading, $\pm 2\%$ F.S.
w	N.C. (4)		
x	N.C. (4)		
y	Airbox Pressure	Pressure XDCR (+)	90 mV/10 PSI(2)
z		Pressure XDCR (-)	$\pm 2\%$ Reading, $\pm 2\%$ F.S.
AA	Air Clnr Pres Drop	Pressure XDCR (+)	50 mV/-5 PSI(2)
AB		Pressure XDCR (-)	$\pm 2\%$ Reading, $\pm 2\%$ F.S.
AC	Fuel Return Pressure	Pressure XDCR (+)	90 mV/100 PSI(2)
AD		Pressure XDCR (-)	$\pm 2\%$ Reading, $\pm 2\%$ F.S.
AE	N.C. (4)		
AF	N.C. (4)		
AG	N.C. (4)		

Notes: (1) Connector per TARADCOM Drawing 12258941. To be mounted in accessible location.
(2) Max Common Mode Voltage on Differential Transducers is 5V. R_{out} $\leq$2K ohms.
Max transducer offset $\pm 15\%$ F.S. Max error $\pm 2\%$ F.S. $\pm 2\%$ Reading.
(3) Code resistor shall be RNR55 type with purchase tolerance of $\pm 0.5\%$
(4) No connection is allowed to these pins.
(5) See Paragraphs 40.2 and 40.3.

Table A4. DCA 11 Six Cylinder Gasoline Engines

Pin No. (1)	Function	Vehicle Connection	Signal
A	N.C. (4)		
B	N.C. (4)		
C	N.C. (4)		
D	New DCA Indicator		
E	Power (+)	Battery Positive Terminal	Power drawn by VTM
F	Power (-)	Chassis Ground at Battery	9-32 VDC 3A Max
G	N.C. (4)		
H	Points	Points, Positive Side	350 VDC Max 10A Max
J	Points Return	Points, Ground	
K	Points Shield		
L	Coil Primary	Coil Primary, Positive	0-32 VDC w.r.W
M	Engine Ground	Engine Ground at Starter	$\pm$2 VDC w.r.W
N	Alt/Gen Out	Alt/Gen Positive Terminal	0-32 VDC w.r. W
O	Alt/Gen Field	Alt/Gen Field Positive Terminal	0-32 VDC w.r. M
P	Alt/Gen Ground	Alt/Gen Ground	$\pm$2 VDC w.r. W
R	N.C. (4)		
S	Starter Solenoid Volts	Starter Solenoid Positive Terminal	0-32 VDC w.r.M
T	Starter Volts	Starter Positive Terminal	0-32 VDC w.r.W
U	"No Sensor"	Unused DCA Channels	-15V Source
V	Battery (+)	Battery Positive Terminal	10-32 VDC
W	Battery (-)	Battery Negative Terminal	
X	N.C. (4)		
Y	N.C. (4)		
Z	Electrolyte No. 1	Battery No. 1	3 VDC Min - 20 VDC Max
a	Electrolyte No. 2	Battery No. 2 or Pin Z	(Lead Cell Probe)
b	Electrolyte No. 3	Battery No. 3 or Pin Z	
c	N.C. (4)		
d	N.C. (4)		
e	N.C. (4)		
f	XDCR Excitation	Pressure Transducer	+12V Source
g	XDCR Excitation Return	Excitation	
h	Code Resistor	845 ohms $\pm$0.5% (3)	
j	Code Resistor Return		
k	N.C. (4)		
m	N.C. (4)		
n	Coolant Temp	Transducer (+)	100 mV/300°F +1.5% F.S.
p		Transducer (-)	
q	N.C. (4)		
r	N.C. (4)		
s	Fuel Filter ΔP	Pressure switch (+)	Switch closure: Low ΔP <1.0 Ohm.
t		Pressure switch (-)	High ΔP = 47K Ohms $\pm$10%
u	Fuel Supply Pressure	Pressure XDCR (+)	90 mV/100 PSI (2)
v		Pressure XDCR (-)	$\pm$2% Reading, $\pm$2% F.S.

Table A4. DCA 11 Six Cylinder Gasoline Engines (Continued)

Pin No. (1)	Function	Vehicle Connection	Signal
w	Intake Manifold Vacuum	Pressure XDCR (+)	54.72 mV/-15 PSI (2)
x		Pressure XDCR (-)	±2% Reading, ±2% F.S.
y	N.C. (4)		
z	N.C. (4)		
AA	N.C. (4)		
AB	N.C. (4)		
AC	N.C. (4)		
AD	N.C. (4)		
AE	N.C. (4)		
AF	N.C. (4)		
AG	N.C. (4)		

Notes: (1) Connector per TARADCOM Drawing 12258941. To be mounted in accessible location.

(2) Max Common Mode Voltage on Differential Transducers is 5V. R_{out} <2K ohms.
Max transducer offset ±15% F.S. Max error ±2% F.S. ±2% Reading.

(3) Code resistor shall be RNR55 type with purchase tolerance of ±0.5%

(4) No connection is allowed to these pins.

Table A5. DCA 13 Optional Second DCA

Pin No. (1)	Function	Vehicle Connection	Signal
A	N.C. (4)		
B	N.C. (4)		
C	N.C. (4)		
D	New DCA Indicator		
E	Power (+)	Battery Positive Terminal	Power drawn by VTM
F	Power (-)	Chassis Ground at Battery	9-32 VDC 3A Max
G	N.C. (4)		
H	N.C. (4)		
J	N.C. (4)		
K	N.C. (4)		
L	Voltage Test No. 7		0-32 VDC w.r. W
M	Engine Ground	Engine Ground at Starter	
N	Voltage Test No. 5		0-32 VDC w.r. W
O	Voltage Test No. 6		0-32 VDC w.r. M
P	N.C. (4)		
R	Voltage Test No. 1		0-32 VDC w.r. M
S	Voltage Test No. 4		0-32 VDC w.r. M
T	Voltage Test No. 3		0-32 VDC w.r. W
U	"No Sensor"	Unused DCA Channels	
V	Voltage Test No. 2		0-32 VDC w.r. W
W	Battery (-)	Battery Negative Terminal	
X	Pressure Test No. 6	Pressure XDCR (+)	90 mV/100 PSI (2)
Y		Pressure XDCR (-)	±2% Reading, ±2% F.S.
Z	Electrolyte No. 1	Battery No. 1	3 VDC Min - 20 VDC Max
a	Electrolyte No. 2	Battery No. 2 or Pin Z	(Lead Cell Probe)
b	Electrolyte No. 3	Battery No. 3 or Pin Z	
c	Pulse Tach (5)	Reed Switch Type	1 pulse/eng. rev. (5)
d	Pulse Tach Return	Contact Bounce 1 ms 50-5000 RPM	Max Noise 1V p-p
e	Pulse Tach Shield		
f	XDCR Excitation	Pressure Transducer	+12V source
g	XDCR Excitation Return	Excitation	
h	Code Resistor	1100 ohms ±0.5% (3)	
j	Code Resistor Return		
k	Temp Test No. 1	Transducer (+)	100 mV/300° F ±1.5% F.S.
m		Transducer (-)	
n	Temp Test No. 2	Transducer (+)	100 mV/300° F ±1.5% F.S.
p		Transducer (-)	
q	N.C. (4)		
r	N.C. (4)		
s	N.C. (4)		
t	N.C. (4)		
u	Pressure Test No. 1	Pressure XDCR (+)	100 mV/300 PSI (2)
v		Pressure XDCR (-)	±2% Reading, ±2% F.S.
w	Pressure Test No. 2	Pressure XDCR (+)	100 mV/3000 PSI (2)
x		Pressure XDCR (-)	±2% Reading, ±2% F.S.

Table A5. DCA 13 Optional Second DCA (Continued)

Pin No. (1)	Function	Vehicle Connection	Signal
y	Pressure Test No. 3	Pressure XDCR (+)	100 mV/3000 PSI (2)
z		Pressure XDCR (-)	±2% Reading, ±2% F.S.
AA	Pressure Test No. 4	Pressure XDCR (+)	90 mV/10 PSI (2)
AB		Pressure XDCR (-)	±2% Reading, ±2% F.S.
AC	Pressure Test No. 5	Pressure XDCR (+)	90 mV/10 PSI (2)
AD		Pressure XDCR (-)	±2% Reading, ±2% F.S.
AE	N.C. (4)		
AF	N.C. (4)		
AG	N.C. (4)		

Notes: (1) Connector per TARADCOM Drawing 12258941. To be mounted in accessible location.

(2) Max Common Mode Voltage on Differential Transducers is 5V. R_{out} ≤2K ohms.
Max transducer offset ±15% F.S. Max error ±2% F.S. ±2% Reading.

(3) Code resistor shall be RNR55 type with purchase tolerance of ±0.5%

(4) No connection is allowed to these pins.

(5) See Paragraphs 40.2 and 40.3.

APPENDIX B

STE/ICE TESTS

Tables

Table B-1. STE/ICE Control and Confidence Tests

Test Select Number	Test	Test Description
		CONTROL FUNCTIONS
01	Interleave	Alternatively displays engine RPM and a second parameter
02	Minimum Value	Displays minimum value detected for next test
03	Maximum Value	Displays maximum value detected for next test
04	Peak-to-Peak Value	Displays Peak-to-Peak value for next test
05	SI Full Power Simulation	Allows evaluation of next selected test on SI engine under full power fuel flow conditions
		CONFIDENCE/ID ENTRY TESTS
58	Number of Cylinder Entry	Permits entry of number of engine cylinders
59	Number of Cylinder Display	Displays number of cylinders entered
60	VID Entry	Permits entry of two digit Vehicle Identification Number (VID). The VID designates engine specific pre-programmed constants for power tests, compression unbalance, and first peak tests
61	VID Display	Displays the VID number entered

Table B-1. STE/ICE Control and Confidence Tests (Continued)

Test Select Number	Test	Test Description
62	DCA ID Display	Reads the vehicle's code resistor and displays the corresponding DCA number. The code resistor selects proper gains, filters, and conversion constants for test applicable to that DCA.
66	Confidence Test	Provides an overall check of the VTM. Displays PASS, FAIL, and fault isolation error messages to assist in DS maintenance.

Table B-2. STE/ICE Tests - DCAs 1 - 12

Test Select Number	Test	Test Description	DCA Test Pins	DCAs
		ENGINE TESTS		
10	Engine RPM (AVE)	Measures average speed of engine crankshaft using Point signal on SI Engine. Pulse Tachometer on CI Engine. Also used to measure cranking speed on CI engine with fuel shut off, i.e., must have means to stop fuel when engine start switch is on.	H,J c,d	10,11,12 1-9
11	Engine RPM, Cranking SI only	Test 11 is only used for measuring cranking RPM. Performed with ignition ON. Automatically inhibits spark plug firing allowing cranking without starting. On CI engines, cranking tests are run using Test 10 with the fuel shut off.	H,J	10,11,12
12	Power Test (RPM/SEC)	Measures engine's power producing potential in units of RPM/SEC. Used when programmed engine constants and corresponding Vehicle Identification Number (VID) have not been established.	H,J c,d	10,11,12 1-9
13	Power Test (% Power)	Measures percentage of engine's power producing potential compared to full power of a new engine.	H,J c,d	10,11,12 1-9
14	Compression Unbalance (%)	Evaluates relative cylinder compression and displays percent difference between the highest and the lowest compression values in an engine cycle. Applicable to SI and CI engines for which VIDs and engine constants have been established.	V,W	1-12

Table B-2. STE/ICE Tests - DCAs 1 - 12 (Continued)

Test Select Number	Test	Test Description	DCA Test Pins	DCAs
		IGNITION TESTS		
16	Dwell Angle (TDC)	Measures number of degrees that the points are closed.	H,J	10-12
17	Points Voltage (VDC)	Measures voltage drop across the points (points positive to battery return).	H,J	10-12
18	Coil Primary Voltage (VDC)	Measures voltage available at the coil positive terminal of the operating condition of the coil.	L,W	10-12
19	Ignition Timing (°TDC)	Measures the crankshaft angle from points opening (plugs fire) to top dead center while cranking the engine. Ignition is automatically inhibited during this test to prevent the engine from firing and distorting the test results.	V,W	10-12
		FUEL/AIR SYSTEM TESTS		
24	Fuel Supply Pressure (psi)	This test measures the outlet pressure of the fuel pump.	u,v	1-12
25	Fuel Return Pressure (psi)	Measures return pressure to detect return line blockage, leaks, or insufficient restrictor back pressure.	AC,AD	1,2,6,7
26	Fuel Filter Pressure Drop (PASS/FAIL)	Detects clogging via opening of a differential pressure switch across the secondary fuel filter. Switch point of DCA standard differential pressure switch will be 13.6 psid unless otherwise designated by vehicle manufacturer.	s,t	1-12

Table B-2. STE/ICE Tests - DCAs 1 - 12 (Continued)

Test Select Number	Test	Test Description	DCA Test Pins	DCAs
27	Fuel Solenoid Voltage (VDC)	Measures the voltage present at the fuel shutoff solenoid positive terminal.	R,M	1-9
28	Air Cleaner Pressure Drop (RIGHT) (In H_2O)	Measures suction vacuum in air intake after the air cleaner relative to ambient air pressure to detect extent of air cleaner clogging.	AA,AB	1-9
29	Air Cleaner Pressure Drop (LEFT) (In H_2O)	Second air cleaner on dual intake systems.	AC,AD	1-9
30	Turbocharger Outlet Pressure (RIGHT) (In Hg)	Measures discharge pressure of the turbocharger.	w,x	1,3-5,8,9
31	Turbocharger Outlet Pressure (LEFT) (In Hg)	Second turbocharger on dual intake systems.	y,z	1,3-5,8,9
32	Airbox Pressure (In Hg)	Measures the airbox pressure of two stroke engines. This measurement is useful in detecting air induction path obstructions or leaks.	y,z	1,2,6,7
33 34	Intake Manifold Vacuum (In Hg) ---------------- Intake Manifold Vacuum Variation (In Hg)	Spark ignition engine intake system evaluation.	w,x	10-12
		LUBRICATION/COOLING SYSTEM TESTS		
35	Engine Oil Pressure (psi)	Self-explanatory	y,z	3,4,8,9

Table B-2. STE/ICE Tests - DCAs 1 - 12 (Continued)

Test Select Number	Test	Test Description	DCA Test Pins	DCAs
36	Engine Oil Filter ΔP	Measures the pressure drop across the engine oil filter as indicator of filter element clogging.	AC,AD	3,4,8,9
37	Engine Oil Temperature (°F)	Primarily applicable to air cooled engines. Requires transducer output shorting switch on vehicle to perform system zero offset test.	k,m	1-9
38	Engine Coolant Temperature (°F)	Transducer output shorting switch on vehicle required.	n,p	1-4, 6-9
STARTING/CHARGING SYSTEM TESTS				
67	Battery Voltage (VDC)	Measure battery voltage at or near battery terminals.	V,W	1-12
68	Starter Motor Voltage (VDC)	Measures the voltage present at the starter motor positive terminal.	T,W	1-12
69	Starter Negative Cable Voltage Drop (VDC)	Measures voltage drop on starter path. A high voltage indicates excessive ground path resistance.	M,W	1-12
70	Starter Solenoid Volts (VDC)	Measures voltage present at the starter solenoid's positive terminal. Measures current through battery ground path shunt.	S,M	1-12
71	Starter Current, Average (amps)	Self-explanatory	X,Y	1-9

Table B-2. STE/ICE Tests - DCAs 1 - 12 (Continued)

Test Select Number	Test	Test Description	DCA Test Pins	DCAs
72	Starter Current First Peak (Peak Amps, DC)	Provides a good overall assessment of complete starting system. Tests condition of the starting circuit and battery's ability to deliver starting current. The measurement is made at the moment the starter is engaged and prior to armature movement. Peak currents higher than the nominal range indicate starter faults. Peak currents less than nominal indicate relatively high resistance caused by poor connections, faulty wiring, or low battery voltage.	X,Y	1-9
73	Battery Internal Resistance (Milliohms)	Evaluate battery condition by measuring battery voltage and current simultaneously.	X,Y V,W	1-9
74	Starter Circuit Resistance (Milliohms)	Measures the combined resistance of the starter circuit internal to the batteries.	X,Y V,W	
75	Battery Resistance Change (Milliohms/sec)	Measures rate of change of battery resistance as an indicator of battery condition.	X,Y V,W	1-9
80	Battery Current	Measures current to or from the battery.	X,Y	1-9
81	Battery Electrolyte Level (PASS/FAIL)	Determines whether electrolyte in the sensed cell is of sufficient level (i.e., in contact with electrolyte probe).	z,a, b,M	1-12
82	Alternator/Generator Output Voltage (VDC)	Self-explanatory	N,W	1-12

Table B-2. STE/ICE Tests - DCAs 1 - 12 (Continued)

Test Select Number	Test	Test Description	DCA Test Pins	DCAs
83	Alternator/Generator Field Voltage (VDC)	Measures voltage present at alternator/generator field windings.	O,M	1-12
84	Alternator/Generator Negative Cable Voltage Drop (VDC)	Measures voltage drop in ground cable and connection between alternator/generator ground terminal and battery negative terminal.	P,W	1-12
85	Alternator Output Current Sense (VAC-RMS)	Measures voltage output at the current transformer in 50 ampere alternator.	L,W	5
86	Alternator AC Voltage Sense (VAC-RMS)	Measures alternator output voltage.	n,p	5

Table B-3. STE/ICE Tests - DCA 13

Test Number	Test	Test Description
01 - 05 58 - 62, 66	Control function Confidence/ID Entry	See Table B-1.
10 12 13 14	Engine RPM Power Test Power Test Compression Unbalance	See Table B-2.
18, 27, 67, 68, 70, 82, 83	Voltage Tests Numbers 1 thru 7	Measure differential voltages of electrical test points on the vehicle referenced to engine ground (Pin M) or battery negative (Pin W) in the range of 0 - 32 volts DC.
37, 38	Temperature Tests Numbers 1 and 2	Measure temperatures in the range of 0 - 300 °F via differential input of 0 - 100 mV.
39 - 44	Pressure Tests Numbers 1 thru 6	Additional pressures in the range of -15 to 10,000 psi. Transducer ranges and outputs per Individual DCA Description for DCA 13. NOTE: Negative Pressure means Vacuum.
81	Battery Electrolyte Level	See Table B-2.

Table B-4. STE/ICE Tests - Transducer Kit Mode

Test Number	Test	Description/Application
01 - 05	Control Functions	See Table B-1.
10 11 12 13 14 15 16 17 19 20 45 46	Engine RPM (Average) Engine RPM (Cranking - SI) Power Test RPM/SEC Power Test % Power Compression Unbalance % (Power Cable) Compression Unbalance % (Test Probe Cable) Dwell Angle °TDC Points Voltage Volts Timing (Power Cable) °TDC Timing (Test Probe Cable) °TDC Vacuum (0 - 30 in) Vacuum Variation (0 - 30 In Hg)	Engine Tests
47	Pressure (0 - 50 In Hg)	Turbocharger and airbox pressures (1).
48	Pressure Drop (0 - 150 In Water)	Suction Vacuum in air intake after air cleaners or intake filters (1).
49	Pressure (0 - 25 psi) Vacuum (0 to -15 psig)	Fuel supply pressure on SI (Spark Ignition) Engines (1).
50	Pressure (0 - 1000 psig)	Pressures in lubrication, fuel, compressed air, power steering or automatic transmissions (2).
51	Pressure (0 - 10,000 psig)	Hydraulic System Pressure (3).
(1) Test uses -15 to +25 psig TK Pressure Transducer (12258877) (2) Test uses 1000 psig TK Pressure Transducer (12258876) (3) Test uses 10,000 psig Pressure Transducer (12258956), available as a supplemental item		
58	Number of Cylinders Entry	Permits entry of number of engine cylinders.
59	Number of Cylinders Display	Primarily used when testing a vehicle not having a Vehicle Identification Number (VID).

Table B-4. STE/ICE Tests - Transducer Kit Mode (Continued)

Test Number	Test	Description/Application
60 61	VID Entry VID Display	See Table B-1.
63 64 66	Transducer ID No. 1 Transducer ID No. 2 Confidence Test	Identifies Transducers connected to Test Cables/Channels 1 and 2.
67 72 & 76 73 & 77 74 & 78 75 & 79	Battery Voltage (VDC) Starter Current First Peak (Amps) Internal Battery Resistance (Millivolts) Starting Circuit Resistance (Milliohms) Battery Resistance Change (Milliohms/sec)	Starting and charging system tests. Measurements made through power cable or test probe cable.
89	DC Voltage (0 - 45.0 Volts)	Enables VTM use as DC voltmeter. The measurements are automatically ranged (autoranged) through three voltage ranges: 0 - 0.5 volts, 0 - 4.5 volts, and 0 - 45.0 volts DC.
90	DC Current (0 - 1500 Amps)	Enables VTM use as a DC ammeter using the TK clamp-on current probe. The ammeter is automatically ranged (autoranged) through three current ranges: 0 - 20 amps, 0 - 150 amps and 0 - 1500 amps DC.
91	0 - 1500 Ohms	Enables VTM use as an ohmmeter in the range from 0 - 1500 ohms for resistance and/or continuity tests
92	0 - 40K Ohms	Enables VTM use as an ohmmeter in the range from 0 - 40,000 ohms. The test value is displayed in thousands of ohms (0.00 - 40.0).

Table B-4. STE/ICE Tests - Transducer Kit Mode (Continued)

Test Number	Test	Description/Application
93	AC Voltage (0 - 35 Volts)	Enables VTM use as an AC voltmeter. Measurements are automatically ranged (autoranged) through three voltage ranges: 0 - 0.5 volts, 0 - 3.5 volts and 0 - 35.0 volts AC.
95	AC Current (0 - 700 Amps)	Enables VTM use as an AC ammeter. Measurements are automatically ranged (autoranged) through three current ranges: 0 - 10 amps, 0 - 70 amps and 0 - 700 amps AC.
96	AC Frequency (40 - 500 Hz)	Enables frequency measurements using the test probe cable.
97	AC Frequency (40 - 500 Hz)	Enables frequency measurements using the current probe.

APPENDIX C

COMPONENT AND TEST POINT LOCATIONS

This appendix provides general information for the location of standard components and test points. Table C-1 describes typical vehicle connections with respect to the Diagnostic Connector pin numbers. Many of the descriptions are further illustrated in the noted figures.

Tables

Figures

Table C-1. Component and Test Point Location

Pin No.	Function	Vehicle Connection/Remarks
A	No Connection	
B	No Connection	
C	No Connection	
D	DCA Indicator	See Chapter 4 and STE/ICE Specification MIL-7-62314(AT), Appendix B, Paragraph 40.2.
E	VTM Power (+)	Battery Positive Terminal: Electrical connection at terminal/cable clamp.
F	VTM Power(-)	Battery Ground: Electrical connection at termination of battery negative cable on hull, chassis or on engine block. Use of twisted pair shielded cable is recommended. Ground shield at or near diagnostic connector. See Figure C-1.
G	No Connection	
H	Points	Ignition Points, Positive Side — See Figure C-2 for electrical connection
J	Points Return	Ignition Points Ground — See Figure C-2 for electrical connection
K	Points Shield	See Figure C-2 for electrical connection
L	Coil Primary	Coil Primary, Positive Terminal — See Figure C-2 for electrical connection
M	Engine/Starter Ground	Electrical connection to Starter Ground terminal on the starter. If starter does not have a ground terminal, connect to starter mounting bolt. See Figure C-3.
N	Alt/Gen Output	Electrical connection to ALT/GEN Positive Terminal. On alternators with separate rectifiers (M113A1) connect to +DC output from rectifier.
O	Alt/Gen Field	Electrical connection ALT/GEN Field Positive Terminal close to alternator.
P	Alt/Gen Ground	Electrical connection at fuel solenoid positive terminal or wire splice in vehicle circuit adjacent to the solenoid.
R	Fuel Solenoid Volts	Electrical connection at fuel solenoid positive terminal or wire splice in vehicle circuit adjacent to the solenoid.

Table C-1. Component and Test Point Location (Cont.)

Pin No.	Function	Vehicle Connection/Remarks
S	Starter Solenoid Volts	Electrical Connection at solenoid coil positive terminal. The connection is at the solenoid closest to the starter armature. It is usually part of the starter assembly but is remotely located on some vehicles. See Figure C-3.
T	Starter Volts	Electrical connection at Starter armature positive terminal. See Figure C-3.
U	"No Sensor"	See Chapter 4 and STE/ICE Specification MIL-T-62314, Appendix B, Paragraph 40.1.
V	Battery Voltage (+)	Electrical connection at Battery Positive Terminal/Cable Clamp. Note that this is the same connection as 'E' but requires a separate wire to the positive terminal. See Figure C-1.
W	Battery Voltage (-)	Electrical connection at Battery Negative Terminal/Cable Clamp. See Figure C-1.
X,Y	Battery/Starter Current	Electrical connections to voltage terminals of current shunt in negative battery cable. See Figure C-1.
Z, a,b	Electrolyte Level	Install Electrolyte Level Sensor in one of the middle cells of the battery, preferably the most positive battery of a series pair. Harness connection to the sensor is through a one-pin connector. Install a 24K ohm resistor between the DCA electrolyte wire and battery ground for each electrolyte level sensor. If there are less than three series pair of batteries, connect Pin b, or Pin a and b to Z at the Diagnostic Connector. See Figure C-1.
c d	CI Engine Speed	Pulse Tachometer 12258931-1 is a double ended unit for vehicles with mechanical instrument panel tachometers. The preferred mounting location is at the tachometer adapter at the engine. For other locations, the flexible drive shaft can be segmented such that the pulse tachometer can be clamped securely at a location relatively close to the engine takeoff. See Figure C-4. 12258931-2 is a single ended unit for vehicles with electrical instrument panel tachometers and is installed at the engine drive for mechanical tachometers. A standard tachometer drive adapter may be required. The normal engine take-off is at the camshaft, providing one pulse per crankshaft revolution on four stroke engines. On two stroke engines the tachometer should be installed after the speed reducer such that the tachometer output will be one pulse per crankshaft revolution. The harness mating to

Table C-1. Component and Test Point Location (Cont.)

Pin No.	Function	Vehicle Connection/Remarks
c d	(cont'd.)	either Pulse Tachometer is through a two pin ITT Cannon Sure Seal Connector.
e	No Connection	Use shielded wire for tachometer connection. Float the shield at the Sure-Seal connector. Connect other end of shield to vehicle chassis ground near the Diagnostic Connector.
f,g	Transducer Excitation and Return	Parallel distribution to bridge type transducers. Connections at transducers are made through a four contact ITT Cannon Sure-Seal Receptacle.
h,j	Code Resistor and Return	Appropriate resistor may be mounted anywhere. Recommended mounting is near the Diagnostic Connector where the Code resistor, DCA Indicator, and "No Sensor" resistors may be grouped.
k,m	Engine Oil Temperature	Install Temperature Sensor 12258933 in engine oil gallery. Location varies with engine and manufacturer. If block must be tapped, installation should be similar to standard SAEJ655 for a SAE Number 1 gage. Tapped hole should be a 1/4-18 DRYSEAL NPTF. See Figure C-5.
n,p	Coolant Temperature	Install in engine block ahead of thermostat. Minimum installation requirements similar to Engine Oil sensor.
q,r	No Connection	
s,t	Fuel Filter ΔP	Install Differential Pressure Switch 12258938 across the secondary fuel filter(s) located between the fuel pump and the injectors or distributor pump. Connect input port of pressure switch to a "TEE" in inlet side of filter. Connect output port to a "TEE" in outlet side of filter. Install a 47K ohm resistor in harness across contacts of switch. Harness connector is a two contact ITT Cannon Sure-Seal Receptacle consisting of: Housing 12258940-2 Contact 12258939-1 Contact 12258939-2 See Figure C-6 and C-7

Table C-1. Component and Test Point Location (Cont.)

Pin No.	Function	Vehicle Connection/Remarks
u,v	Fuel Supply Pressure	Install in "TEE" in fuel line after fuel pump. Harness connector is a four contact ITT Cannon Sure-Seal receptable consisting of: Housing 12258940-4 Contact 12258939-1 Quantity 2 Contact 12258939-2 Quantity 2 See Figures C-6 and C-7
w,x, y,z	Turbocharger Outlet Pressure CI Engine	Tap 1/4-18 NPT into turbocharger housing or intake manifold downstream of turbocharger outlet. If a manifold pressure tap exists in the intake manifold, insure that it is not downstream of the flame heater. See Figure C-8. Harness connector is four contact Sure-Seal Receptacle.
w,x	Manifold Vacuum SI Engines	Intake manifold normally has a tapped access hole. Install a snubber 12258881 between manifold and the -15 psig pressure transducer per 12258932-1. Harness connector is four contact Sure-Seal Receptacle.
y,z	Air Box Pressure Two stroke CI Engine	Install appropriate transducer per 12258932 into tapped access hole in engine block. Adaptive fittings may be required to accommodate thread size or space limitations. Harness connector is four contact Sure-Seal Receptacle.
y,z	Oil Pressure	Install pressure transducer into existing or tapped hole into engine block oil gallery. Comments for (y, z) above apply.
AA, AB, AC, AD	Air Cleaner ΔP	Install pressure transducer 12258932-2 after air filter element in air cleaner housing or air intake ducting. Harness connector is a four contact Sure-Seal Receptacle. See Figure C-9.
AC, AD	Fuel Return Pressure	Install pressure transducer in "TEE" in fuel return line before the restrictor. On some engines, the fuel restrictor may have to be relocated downstream to accommodate this installation. Harness connector is a four contact Sure-Seal Receptacle. See Figure C-6.
AC, AD	Oil Filter ΔP	Install multipoint differential pressure switch 12258934 across oil filter. Installation similar to fuel filter ΔP. However, harness connector is four contact Sure-Seal Receptacle.
AE	No Connection	
AF	No Connection	
AG	No Connection	Transducer Shield - See Figure C-9.

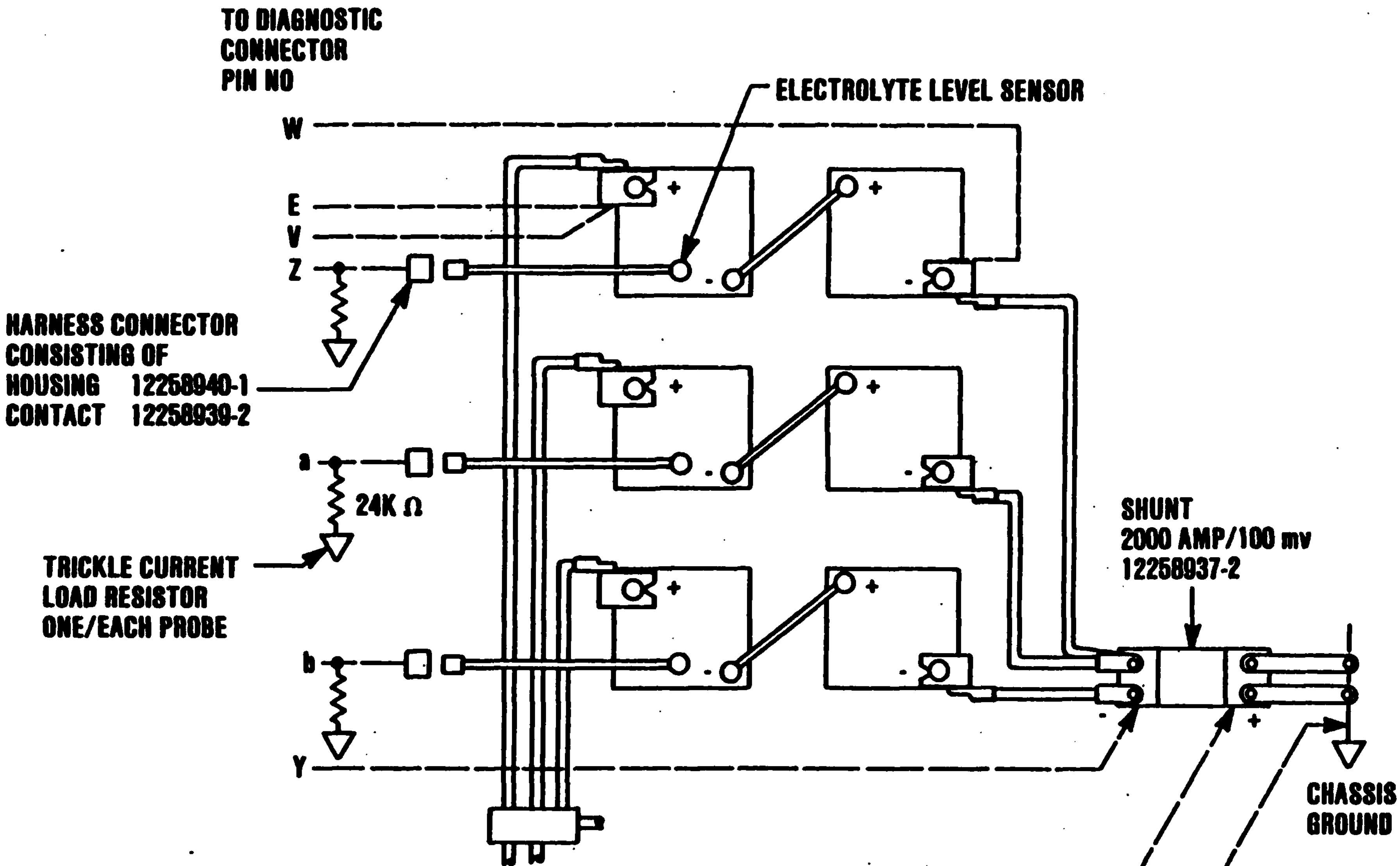

Figure C-1. Battery Connections (Typical for M48A3/M60 - DCA #5)

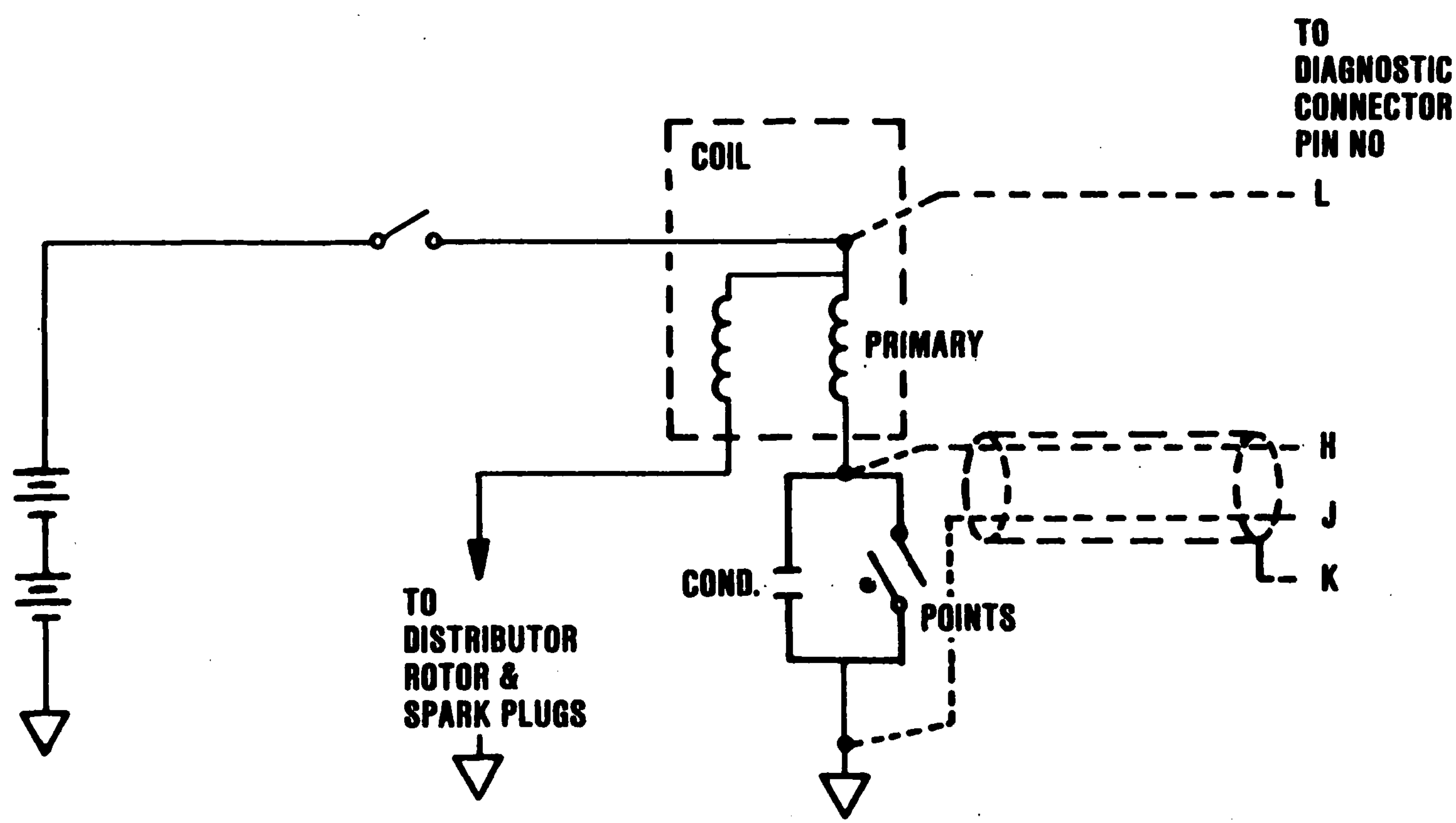

Figure C-2. Ignition System Connections (Typical for M151A2)

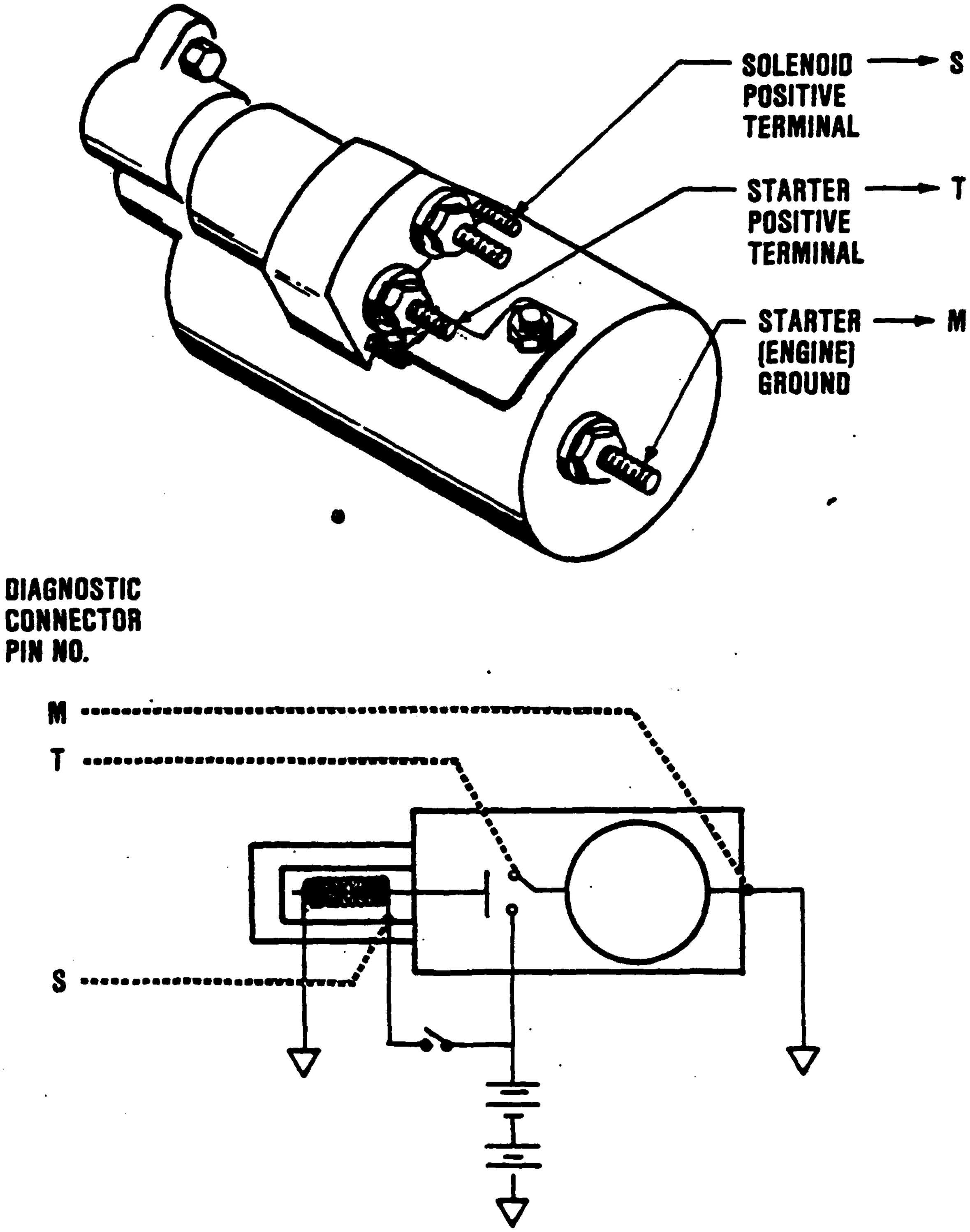

Figure C-3. Starter/Engine Ground Connections

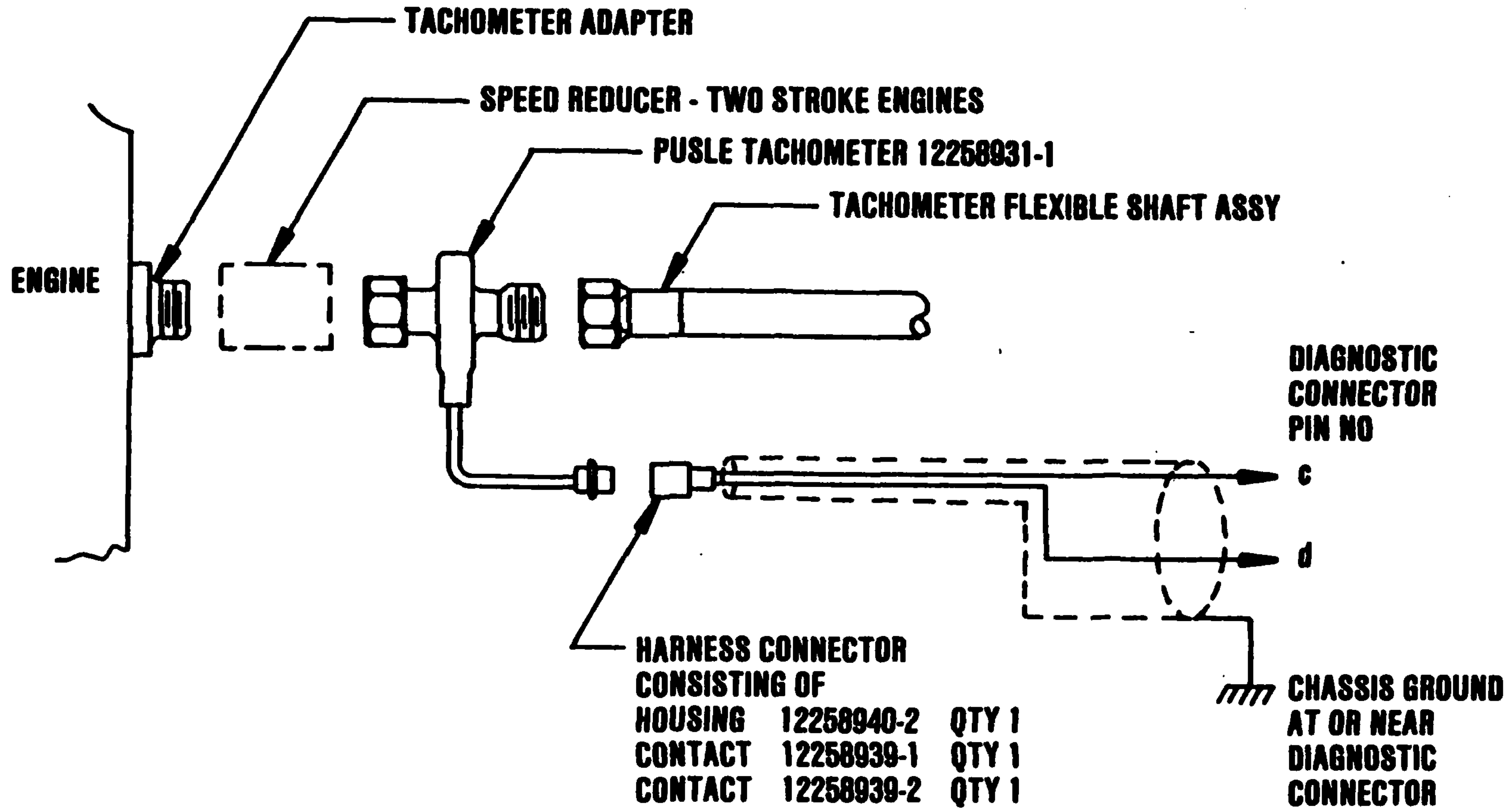

Figure C-4. CI Engine Speed

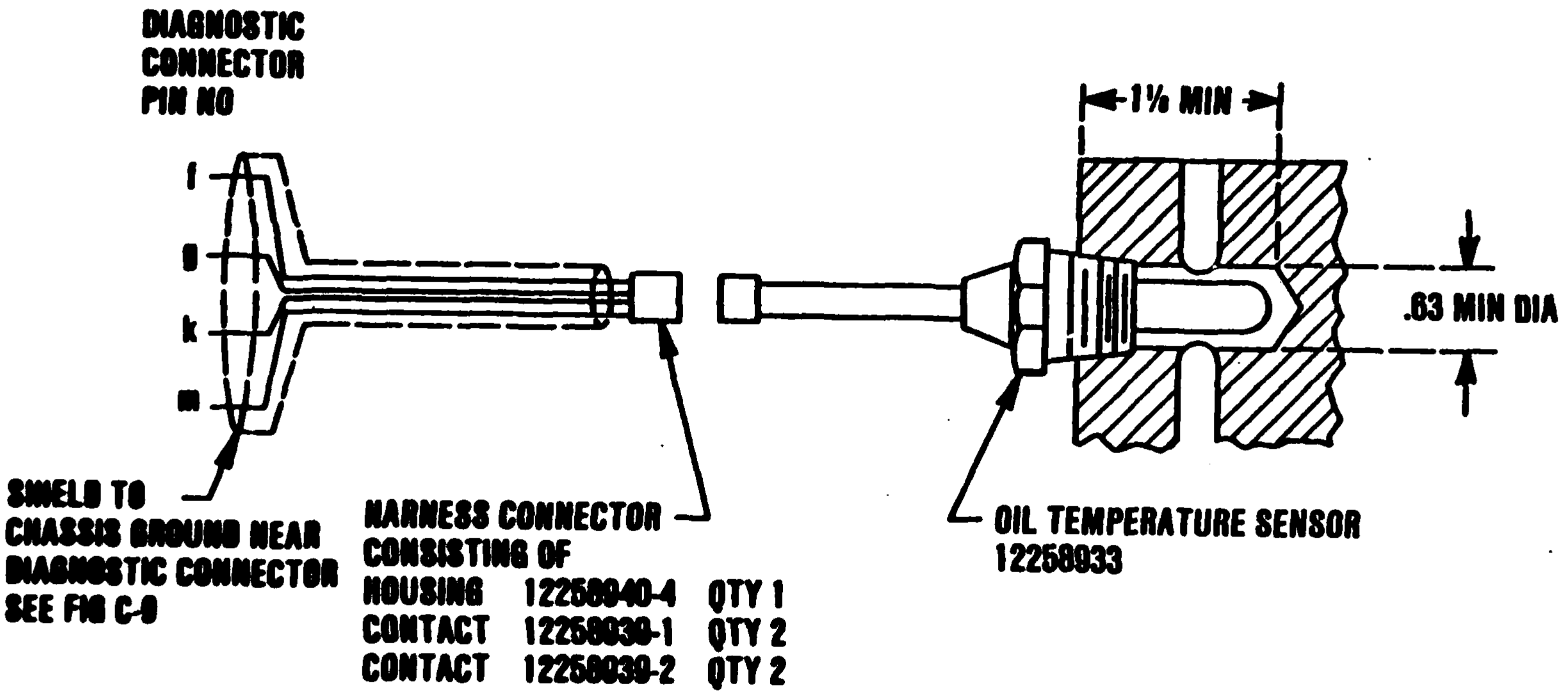

Figure C-5. Engine Oil Temperature

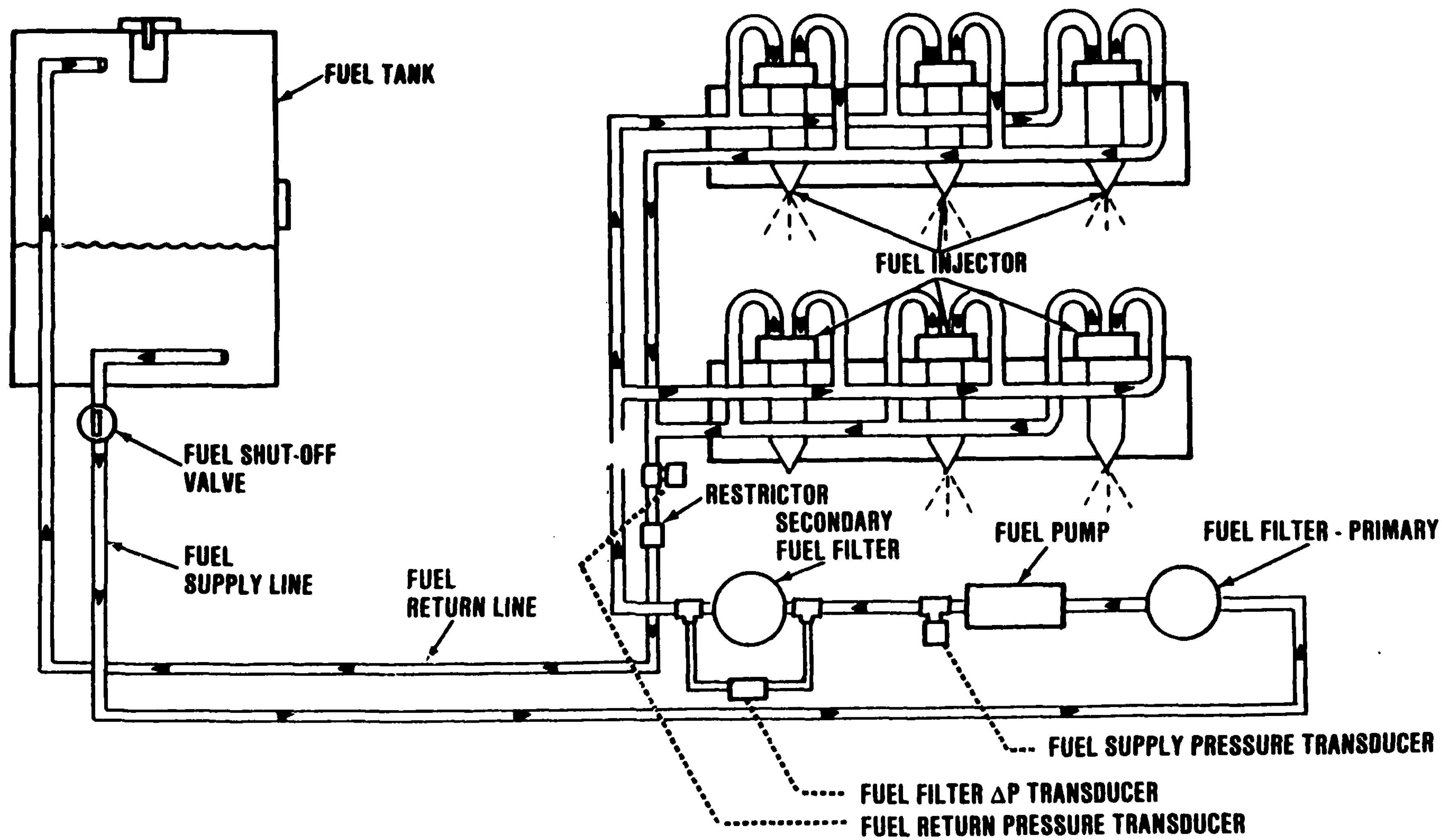

Figure C-6. Unit Injector Fuel System

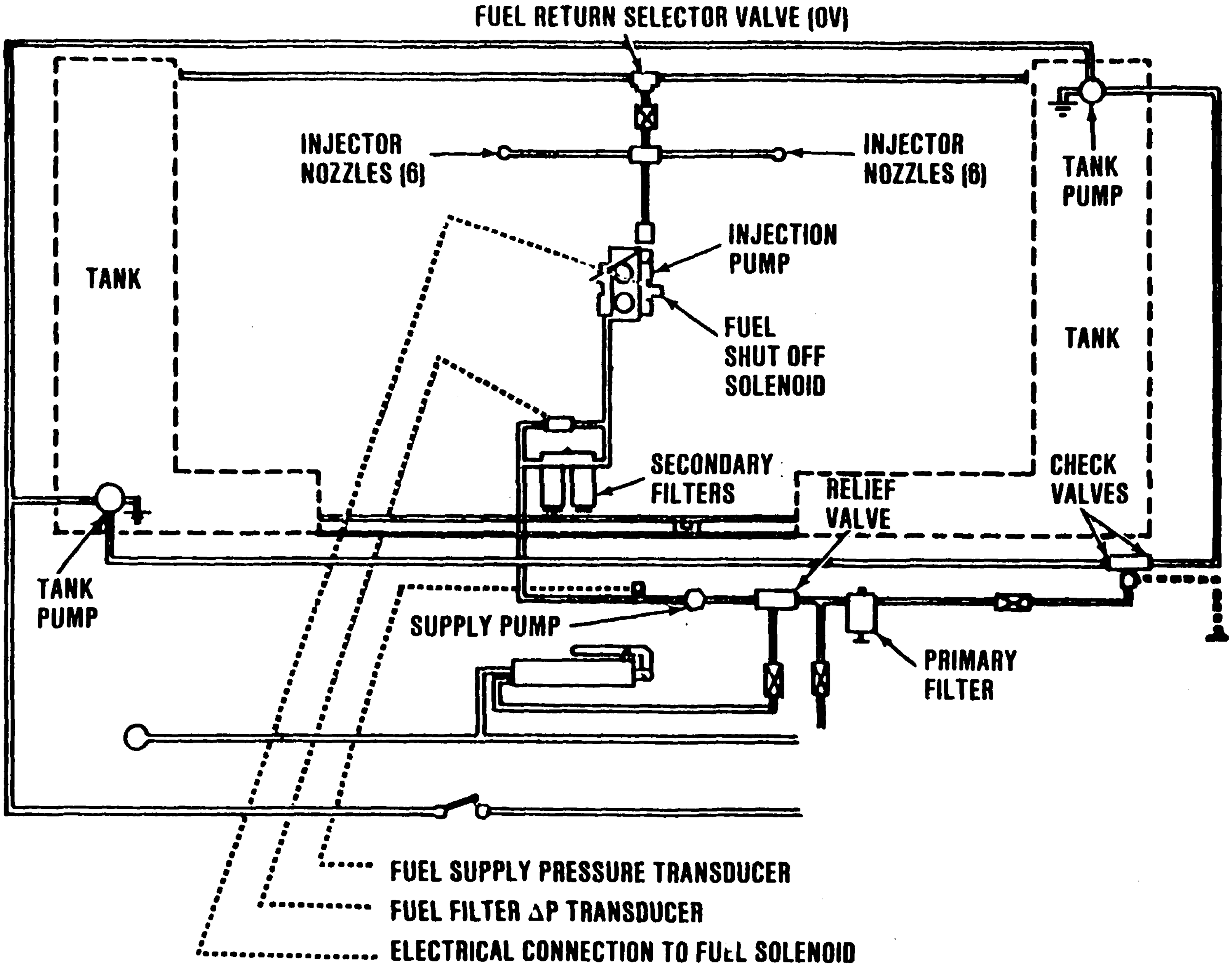

Figure C-7. Distributor Pump Type Fuel System

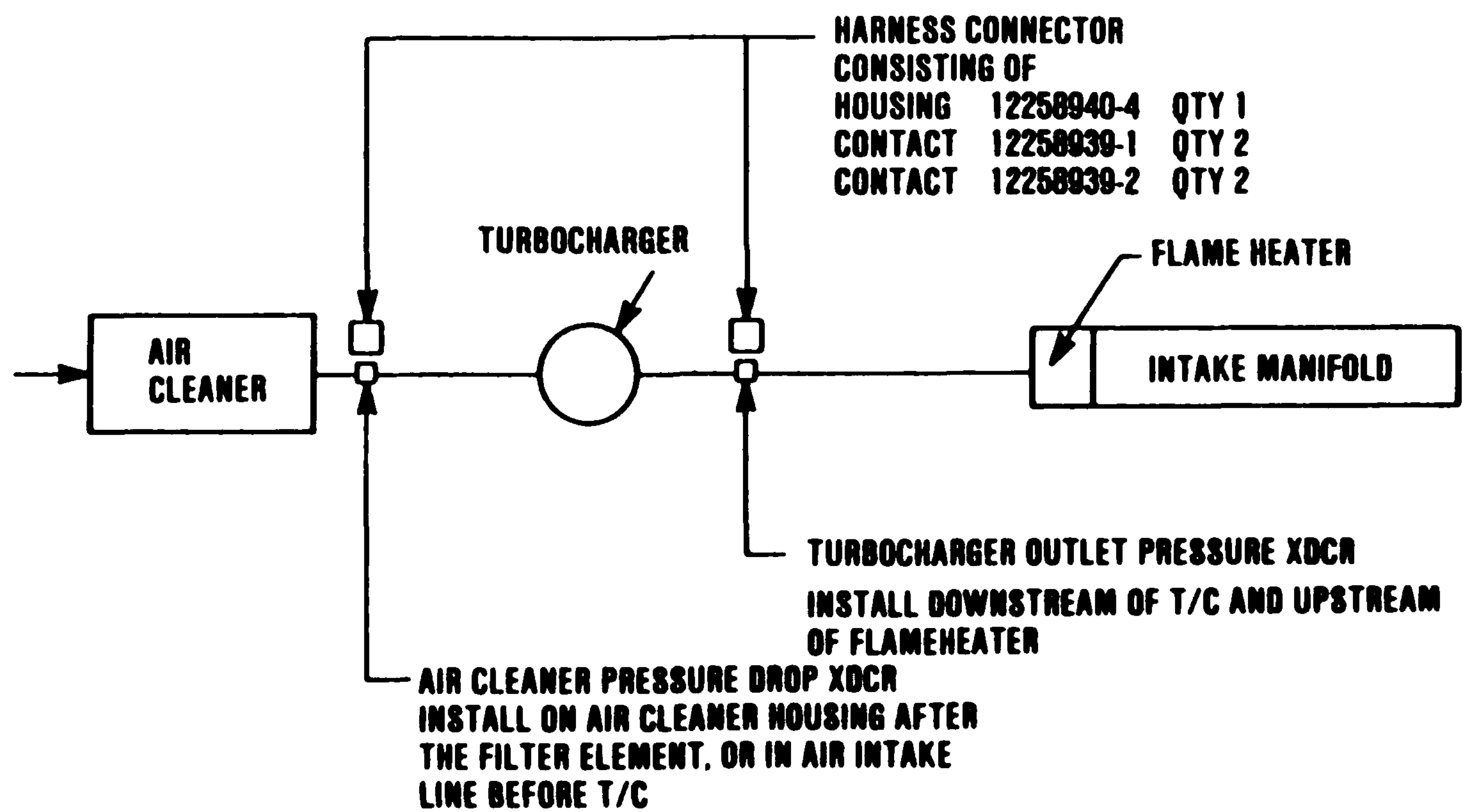

Figure C-8. Air Intake System

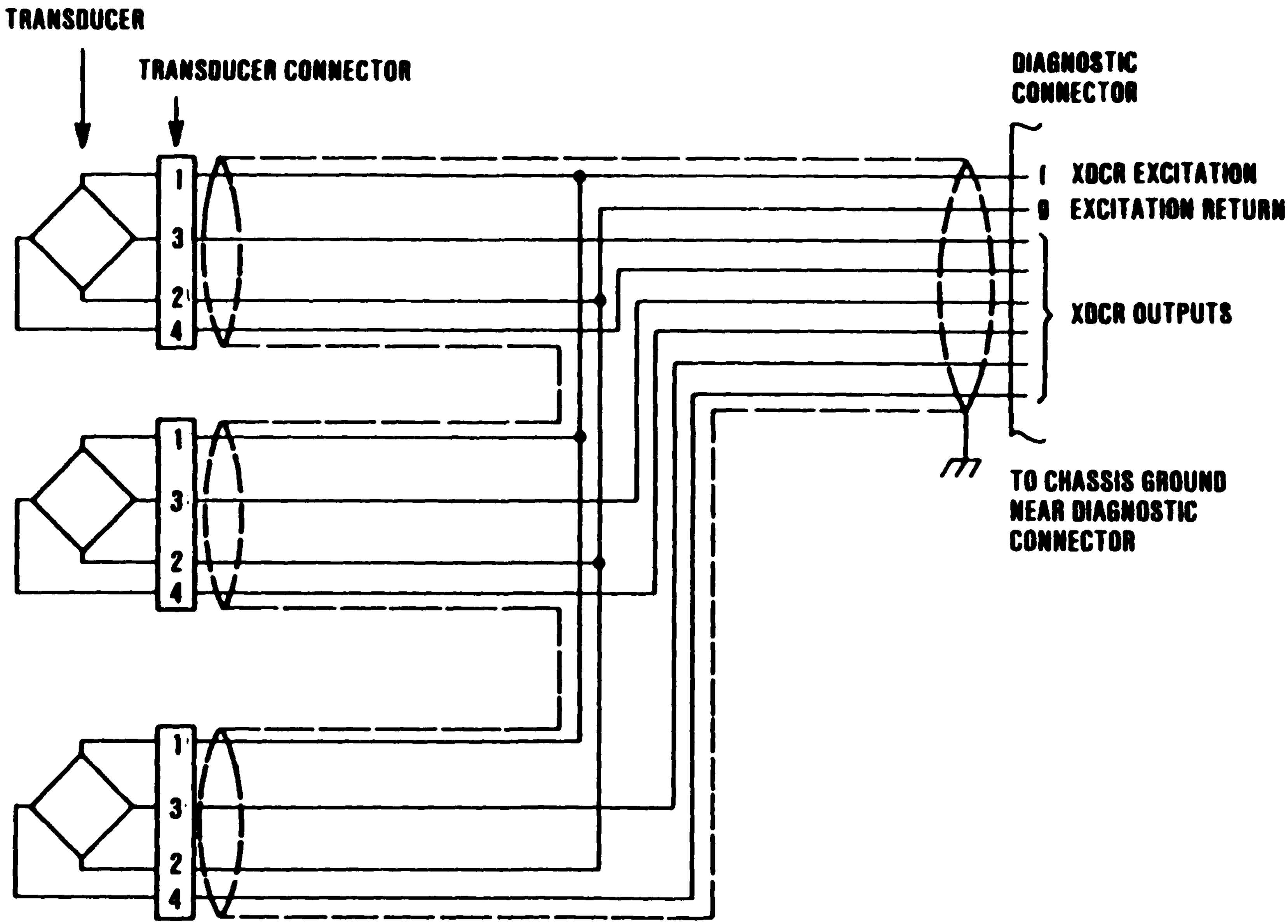

Figure C-9. Transducer Shielding

APPENDIX D

ABBREVIATIONS AND ACRONYMS

AC	Alternating Current
ALT (alt)	Alternator
AMP (amps)	Amperes
AWG	American Wire Gauge
C	Celsius
CAL	Prompting message on VTM for performance of offset test and display of offset value, (Zero Offset correction)
CI	Compression Ignition (Diesel)
COND	Condenser
CONUS	Continental United States
CPU	Central Processing Unit
CYL	Prompting message on VTM that informs operator to dial in the number of cylinders
DC (dc)	Direct Current
DCA	Diagnostic Connector Assembly
DCA ID	DCA Identification Number
DS	Direct Support
F	Fahrenheit
GEN (gen)	Generator
GO	Prompting message on VTM that informs the operator to proceed with test
HG (Hg)	Mercury
HZ	Hertz
H_2O	Water
ID	Identification Number
IN (in.)	Inch(es)
K (k)	Thousand
m Ohm	Milliohms
mV	Millivolts
PSI (psi)	Pounds per Square Inch
PSIA (psia)	Pounds per Square Inch, Absolute; Pressure relative to zero pressure, i.e., Complete Vacuum
PSID (psid)	Pounds per Square Inch, Differential

PSIG (psig)	Pounds per Square Inch, Gage; Pressure relative to ambient pressure
PSIS (psis)	Pounds per Square Inch, Sealed; Pressure relative to a sealed pressure
PVC	Polyvinyl Chloride
P-P	Peak-to-Peak
RAM	Random Access Memory
RPM	Revolutions Per Minute
RTD	Resistive Temperature Device
SAE	Society of Automotive Engineers
SDR	System Development Requirement
SEC (sec)	Second
SI	Spark Ignition (Gasoline)
Spec	Specification
STE/ICE	Simplified Test Equipment/Internal Combustion Engines
STE-T	Simplified Test Equipment - Tracked
Tach (tach)	Tachometer
TACOM	U.S. Army Tank-Automotive Command
TDC	Top Dead Center
TEMP	Temperature
TK	Transducer Kit
TM	Technical Manual
T/C	Turbocharger
VAC	Volts Alternating Current
VDC (vdc)	Volts Direct Current
VID	Vehicle Identification Number
VTC	Vehicle Test Cards
VTM	Vehicle Test Meter
SDCR	Transducer
ΔP	Differential Pressure